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Research article

Relationship between Final Performance and Block Times with the Traditional and the New Starting Platforms with A Back Plate in International Swimming Championship 50-M and 100-M Freestyle Events

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Abstract

The purpose of this study was to investigate the association between block time and final performance for each sex in 50-m and 100-m individual freestyle, distinguishing between classification (1st to 3rd, 4th to 8th, 9th to 16th) and type of starting platform (old and new) in international competitions. Twenty-six international competitions covering a 13-year period (2000-2012) were analysed retrospectively. The data corresponded to a total of 1657 swimmers' competition histories. A two-way ANOVA (sex × classification) was performed for each event and starting platform with the Bonferroni post-hoc test, and another two-way ANOVA for sex and starting platform (sex × starting platform). Pearson's simple correlation coefficient was used to determine correlations between the block time and the final performance. Finally, a simple linear regression analysis was done between the final time and the block time for each sex and platform. The men had shorter starting block times than the women in both events and from both platforms. For 50-m event, medalists had shorter block times than semi-finalists with the old starting platforms. Block times were directly related to performance with the old starting platforms. With the new starting platforms, however, the relationship was inverse, notably in the women's 50-m event. The block time was related for final performance in the men's 50-m event with the old starting platform, but with the new platform it was critical only for the women's 50-m event.

Key words: Swimming, performance, start time.

Introduction

The goal of a swimming event is to complete the distance in the shortest time possible. Some events are won or lost by hundredths of a second. In evaluating a swimmer's performance, several aspects have to be taken into account such as final time, strategy, and technical components (Maglischo, 2003). These last include speed, stroke mechanics, starting, turning, and finishing (Arellano et al., 1994). The start is the fastest phase of a swimming race, and its effective performance is an essential part of competitive swimming, particularly in the shorter sprint events (Cossor and Mason, 2001). Even though the time the swimmer spends in the start is much less than in the free swim, it can be important for final success, representing between 0.8% and 26.1% of the overall race time depending on the event (Mason and Cossor, 2000).

There have been numerous studies in recent years on the start in swimming, with analyses of the different techniques used – grab, track, one-handed track, and new kick starts (Blanksby et al., 2002; Galbraith et al., 2008; Honda et al., 2010; Issurin and Verbitsky, 2003; Slawson et al., 2011; 2013) – and their phases (Cossor and Mason, 2001; Mason and Cossor, 2000; Seifert et al., 2007; 2010). The introduction of the new Omega OSB11 start blocks (FR 2.7 Starting Platforms in FINA's rules) that features an "adjustable, slanted footrest" has led to new studies (Honda et al., 2010; Nomura et al., 2010; Takeda et al., 2012) which make no reference to the grab start. This platform was first used in the World Championships held in Rome (Italy) in 2009. Traditionally, the time that a swimmer spends starting may be taken as the time from the starting signal being given until the feet leave the starting platform (the block time), plus the time until first contact is made with the water (the flight time), plus the time from first contact with the water until the swimmer begins kicking and/or stroking (glide or underwater time) (Hay, 1986). Several studies have assessed these parameters by the time until a fixed distance (7.5, 10 or 15 m) (Blanksby et al., 2002; Seifert et al., 2010; Welcher et al., 2008). The block time itself is the combination of reaction time (the interval between the starting signal and the first movement on the block) and movement time (vertical and horizontal force off the block), in total being the time difference from the starting signal to when the swimmer's feet leave the block (Sanders, 2002). With respect to the reaction time, various studies have looked at the possibility of reducing it by focusing training on attention to either the starting signal or the motor response (Buckolz, 1980; Buckolz and Vigarhe, 1987). As the starting signal is easily identified, the start may be anticipated to reduce reaction time (Collet, 1999). Minimizing the RT has been suggested to be a relevant factor for final success (Brown et al., 2008).

A recent study on swimming evaluated the impact of different warm-ups on performance, reaction time, and dive distance in 50-yard sprints, finding that there were no differences in reaction time between the different warm-ups, including if there was no warm-up at all (Balilionis et al., 2012). This suggests that specific work on reaction time is needed for it to be reduced. Movement time may be trainable with lower body strength and power training (West et al., 2011). Coaches should consider including

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regular dive practice sessions (Blanksby et al., 2002) and plyometric sessions (Bishop et al., 2009) to improve swimmers' block time (reaction time plus movement time). At the end of each race, the official results show the final times and the block times. This information can be analysed by the coach and the swimmer together immediately for the following phases of the competition (semi-finals and final). In synthesis, a good start requires a fast reaction time and excellent jumping power (block time), together with low resistance during the underwater glide and good propulsion (below and on the surface) (Maglischo, 2003). In the 50-m and 100-m individual freestyle events, being those of shortest duration in the Olympics calendar, the first places are often decided in hundredths of a second. Therefore, it seemed interesting to analyse how the block time influences the final result, especially after the inclusion of the new platforms with a back plate (Omega OSB11 starting blocks). To the best of the authors' knowledge, no study has as yet analysed how block time (reaction time plus movement time) influences the final time in 50-m and 100-m individual freestyle races in a large sample of international competitions. For this reason, the purpose of the present work was to investigate the association between block time and final performance in each sex (men and women) and as a function of classification (1st to 3rd, 4th to 8th, 9th to 16th) and type of starting platform (old and new) in international competitions during the last 13 years.

Methods

Subjects

Twenty-six international competitions were analysed: four Olympic Games (2000, 2004, 2008 and 2012), six World Championships (2001, 2003, 2005, 2007, 2009 and 2011), seven European Championships (2000, 2002, 2004, 2006, 2008, 2010 and 2012), two Commonwealth Games (2006 and 2010), two Pan Pacific Games (2006 and 2010), three U.S. Olympic Team Trials (2004, 2008 and 2012), and two Australian Olympic Trials (2000 and 2012). Of these 26 championships, 18 used the old starting platforms and 8 the new Omega OSB11 start blocks (since 2009). This was thus a retrospective analysis covering a 13-year period (2000-2012). Of the possible 1664 swimmer records (26 international competitions × 16 swimmers × 2 sexes × 2 events [50-m and 100-m individual freestyle]), 1657 records were analysed (1021 old platforms and 636 new) because there were seven disqualified swimmers whose results were not included in the official listings.

Procedures

All the results were retrieved from the Websites of the corresponding championships, and are in the public domain. No informed consent from swimmers was therefore necessary for the use of this information. In 22 of the 26 championships, we used the respective official timekeeping page (http://www.omegatiming.com/). Of the remaining two championships, one (Commonwealth Games 2010) was analysed using the results of the official Website of the event organizer (http://www.cwgdelhi2010.org/), and the other (2008 and 2012 Olympic Games, and 2012 Australian Olympic Trials) using data taken from a Website specializing in swimming rankings (http://www.swimrankings.net/). The block time was provided by the official competition timing system (the time that a swimmer spends starting may be taken as the time from the starting signal being given until the feet leave the starting platform). This information is recorded in real time. The starting platform has a mechanical contact switch mounted between the top of the starting clock and the base. The switch is closed when the subject stands on the platform and opens when the swimmer's feet leave the block following the starting gun (Tanner, 2001). The times are expressed with a precision of 0.01 s. The results of five International Championships that were held in the study interval (Commonwealth Games 2002; Pan Pacific Games 2002; U.S. Olympic Team Trials 2000; and Australian Olympic Trials 2004, 2008) were not included since their official data did not report the swimmers' block time. The data were retrieved by one of the authors (AGH), and entered manually into an Excel spreadsheet file. They were then subjected to a random check by another of the authors (YE) to detect possible errors. The use of data that is publicly available on official Websites is usual in the field of analysis of water sports performance (Costa, et al., 2010; Escalante et al., 2011; Escalante et al., 2012; Escalante 2013; Robertson et al., 2009; Saavedra et al., 2012).

Statistical analysis

Basic descriptive statistics (mean and standard deviation) were used to characterize the sample with respect to both final times and block time. The normality of the data was confirmed by a Kolmogorov-Smirnov test. Two-way ANOVAs (sex [men and women] × classification [3 levels: 1st to 3rd, 4th to 8th, 9th to 16th]) were performed for each event (50-m and 100-m individual freestyle) and type of starting platform (old and new). The Bonferroni post-hoc test was used to compare means. Analyses based on the final classification of the championship have been carried out in swimming (Saavedra et al., 2012) and in other sports such as rowing (Muehlbauer et al., 2010). They are particularly relevant for the Olympics in which, besides the medals (1st to 3rd place), Olympic diplomas are awarded (4th to 8th), and semifinals are swum (9th to 16th). Two-way ANOVAs [sex (men and women) and starting platform (new and old)] were also performed.

The eta-squared (η^2) statistic, which describes the proportion of the variability attributable to a given factor, was calculated. Since multiple comparisons are made, in order to avoid incorrectly rejecting the null hypothesis, we applied the Bonferroni correction. This takes $\alpha = 0.05/K$, where K is the number of groups (Bland and Altman, 1995). In the present study, the number of groups was six (3 classifications × 2 sexes) in each event (50-m and 100-m freestyle) and for each starting platform (old and new). Hence, with K=6, the result of a comparison is considered significant if $p < 0.008$.

Pearson's simple correlation coefficient was used to study possible correlations between block time and final performance both for each group (1st to 3rd, 4th to

Table 1. Mean, standard deviation (time), two-way ANOVA (sex, classification, and interactions) with Bonferroni *post-hoc* in 50 m and 100 m individual freestyle in old starting platform.

	Time (s)			Block time (s)				
	Men (m) (n=511) Mean (SD)		**Women (w) (n=510) Mean (SD)**	**Men (m) (n=511) Mean (SD)**			**Women (w) (n=510) Mean (SD)**	
50-m freestyle								
1st-3rd (n=96)	22.10 (.23)		24.94 (.45)	.73 (0.06)			.76 (0.05)	
4th-8th (n=157)	22.45 (.27)		25.46 (.41)	.75 (0.07)			.77 (0.06)	
9th-16th (n=256)	22.77 (.36)		25.86 (.44)	.76 (0.06)			.79 (0.06)	
100-m freestyle								
1st-3rd (n=96)	48.64 (.43)		54.40 (.64)	.75 (0.06)			.77 (0.06)	
4th-8th (n=160)	49.37 (.50)		55.31 (.66)	.76 (0.05)			.78 (0.06)	
9th-16th (n=256)	50.07 (.68)		56.18 (.79)	.77 (0.05)			.79 (0.06)	
Whole sample by sex and classification	**Sex**			**Classification**				
	Men (m)		**Women (w)**	**1st -3rd (a)**		**4th -8th (b)**		**9th -16th (c)**
50-m freestyle	.75 (.06)		.78 (.06)	.75 (0.05)		.76 (0.07)		.77 (.06)
100-m freestyle	.76 (.05)		.79 (.06)	.76 (0.06)		.77 (0.05)		.78 (.05)
Main effects and interactions	**Sex**			**Classification**			**Sex * Classification**	
	F	**Diff**	**p**	**F**	**Diff**	**p**	**F**	**p**
50-m freestyle	18.141	m<w	**<.001**[a]	5.205	a<c	**.006**[c]	.567	.568
100-m freestyle	24.035	m<w	**<.001**[b]	4.100	a<c	.017	.085	.918

a: effect size=-0.50; b: effect size=-0.54; c: effect size=-0.35

8th, 9th to 16th) and for the whole sample (1st to 16th). This type of analysis has been used in previous studies (Bishop et al., 2009; Breed and Young, 2003; Saavedra et al., 2012; West et al., 2011), and allows a simple relationship between block time and performance to be established. Finally, a simple linear regression was performed between the final time and the block time for each sex and platform. All analyses were performed using the computer software Statistical Package for Social Sciences (SPSS) version 15.0.

Results

Table 1 presents the results corresponding to 50-m and 100-m individual freestyle events with the old starting platforms. In both events, the men's block time were shorter than those of the women (50-m individual freestyle, $p < 0.001$, $\eta^2 = 0.03$; 100-m individual freestyle, $p < 0.001$, $\eta^2 = 0.04$). With regard to the classification, the medalists (1st to 3rd) had shorter block time than the semi-finalists (9th to 16th) in the 50-m event ($p = 0.006$, $\eta^2 = 0.02$). There were no significant interactions between sex and classification in the 50-m ($F = 0.567$, $p = 0.568$) and 100-m ($F = 0.085$, $p = 0.918$) events.

Table 2 presents the analogous results corresponding to the new starting platforms. In both events, the men's block time were shorter than those of the women (50-m individual freestyle, $p < 0.001$, $\eta^2 = 0.10$; 100-m individual freestyle, $p < 0.001$, $\eta^2 = 0.13$). There were no significant differences with respect to classification or interactions (sex × classification).

Table 3 presents the results for both events and starting block platform. In both events, the block times of men and all subjects on the new platform were shorter than those of women (50-m individual freestyle, $p < 0.001$, $\eta^2 = 0.04$; 100-m individual freestyle, $p < 0.001$, $\eta^2 = 0.07$) and of all subjects on the old platforms (50-m individual freestyle, $p < 0.001$, $\eta^2 = 0.26$; 100-m individual freestyle, $p < 0.001$, $\eta^2 = 0.23$), respectively. There were no significant differences with respect to interactions (sex × starting block platform).

Table 4 presents the correlations between the values of block time and the final performance (total time and total records) with the two platforms. For the old starting platforms, there were significant direct correlations for men in the 50-m event for the medalists ($p = 0.003$) and 9th-16th placed ($p = 0.004$) and in 100-m only for the 4th-8th placed ($p < 0.001$), and for women, in the 50-m event for the 4th-8th placed ($p = 0.001$) and 9th-16th placed ($p = 0.001$) and in 100-m only for the 9th-16th placed $p = 0.005$). When the overall sample (the top 16) was analyzed, a direct relationship was found for both sexes in both the 50-m (men: $r = 0.278$; $p < 0.001$; women: $r = 0.223$; $p < 0.001$) and the 100-m (men: $r = 0.302$; $p < 0.001$; women: $r = 0.247$; $p < 0.001$) events. For the new starting platforms, there were significant inverse correlations for men in the 50-m event for the semi-finalists ($r = -0.368$; $p = 0.011$) and in 100-m also for the semi-finalists ($r = -0.368$; $p = 0.048$), and for women, only for the medalists in the 50-m event ($r = -0.572$; $p = 0.007$). In the analysis of the overall sample, there were significant inverse correlations for men ($r = -0.164$; $p = 0.039$) and women ($r = -0.162$; $p = 0.041$) in the 50-m event.

Finally, Figure 1 shows the relationship between final performance (time) and block time by sex for the old platform type ($p < 0.001$). No figures for the new platform are shown because the relationship in these cases was not significant ($p > 0.05$).

Table 2. **Mean, standard deviation (time), two-way ANOVA (sex, classification, and interactions) with Bonferroni *post-hoc* in 50 m and 100 m individual freestyle in new starting platform.**

	Time (s)		Block time (s)	
	Men (m) (n=318) Mean (SD)	Women (w) (n=318) Mean (SD)	Men (m) (n=318) Mean (SD)	Women (w) (n=318) Mean (SD)
50-m freestyle				
1st-3rd (n=60)	21.7 (.29)	24.5 (.34)	.68 (.04)	.70 (.05)
4th-8th (n=100)	22.1 (.35)	25.0 (.44)	.68 (.04)	.70 (.05)
9th-16th (n=158)	22.4 (.45)	25.4 (.55)	.68 (.05)	0.72 (.05)
100-m freestyle				
1st-3rd (n=60)	48.0 (.60)	53.7 (.55)	.69 (.03)	.73 (.04)
4th-8th (n=100)	48.6 (.62)	54.5 (.74)	.69 (.04)	.73 (.05)
9th-16th (n=158)	49.2 (.72)	55.1 (.85)	.71 (.04)	.74 (.05)

Whole sample by sex and classification	Sex		Classification		
	Men (m)	Women (w)	1st -3rd (a)	4th -8th (b)	9th -16th (c)
50-m freestyle	.68 (0.04)	.71 (0.05)	.69 (0.04)	.69 (0.05)	.70 (.05)
100-m freestyle	.70 (0.04)	.73 (0.05)	.71 (0.04)	.71 (0.05)	.72 (.05)

Main effects and interactions	Sex			Classification			Sex * Classification	
	F	Diff.	p	F	Diff.	p	F	p
50-m freestyle	26.932	m<w	**<.001**[a]	1.740	n.s.	.177	.809	.446
100-m freestyle	41.328	m<w	**<.001**[b]	2.144	n.s.	.119	.541	.583

a: effect size=-0.66; b: effect size=-0.66

Table 3. **Mean, standard deviation (time), two-way ANOVA (sex, and starting block) with Bonferroni *post-hoc* in 50-m and 100-m individual freestyle.**

	Time (s)		Block time (s)	
	Men (m) (n=829) Mean (SD)	Women (w) (n=827) Mean (SD)	Men (m) (n=829) Mean (SD)	Women (w) (n=827) Mean (SD)
50-m freestyle				
Old platform (n=509)	22.5 (.41)	25.6 (.55)	.75 (.64)	.77 (.06)
New platform (n=318)	22.1 (.47)	25.1 (.61)	.68 (.44)	.71 (.47)
100-m freestyle				
Old platform (n=511)	49.6 (.80)	55.6 (.99)	.76 (.05)	.79 (.06)
New platform (n=318)	48.8 (.82)	54.6 (.94)	.70 (.04)	.73 (.05)

Whole sample by sex and starting block	Sex		Starting block	
	Men (m)	Women (w)	Old (a)	New (b)
50-m freestyle	.72 (.07)	.75 (.06)	.76 (.06)	.69 (.05)
100-m freestyle	.74 (.06)	.77 (.06)	.77 (.06)	.72 (.05)

Main effects and interactions	Sex			Starting block			Sex * Starting block	
	F	Diff.	p	F	Diff.	p	F	p
50-m freestyle	46.262	m<w	**<0.001**[a]	291.859	a>b	**<0.001**[c]	.278	.598
100-m freestyle	61.412	m<w	**<0.001**[b]	244.563	a>b	**<0.001**[d]	1.825	.177

a: effect size=-0.46; b: effect size=-0.50; c: effect size=1.24; d: effect size=0.89

Table 4. **Pearson's linear simple correlation (*r*) for block time significantly correlated with performance (time) in old and new starting platform.**

Starting platform		50-m freestyle		100-m freestyle	
		Men	Women	Men	Women
Old	1st – 3rd	**.426****	.045	.200	.153
	4th -8th	.220	**.361****	**.386*****	.190
	9th -16th	**.254****	**.292****	.119	**.241****
New	1st – 3rd	-.136	**-.572*****	-.264	-.144
	4th -8th	-.127	-.268	-.102	-.259
	9th -16th	**-.307***	-.030	**-.280***	.053

Discussion

This study has examined the association between block time and final performance in each sex (men and women) and as a function of classification (1st to 3rd, 4th to 8th, 9th to 16th) and type of starting platform (old and new) in international competitions. To the best of our knowledge, it is the first study of this type. Knowledge of the relationship between block time and final performance in these events would allow coaches to consider in greater depth

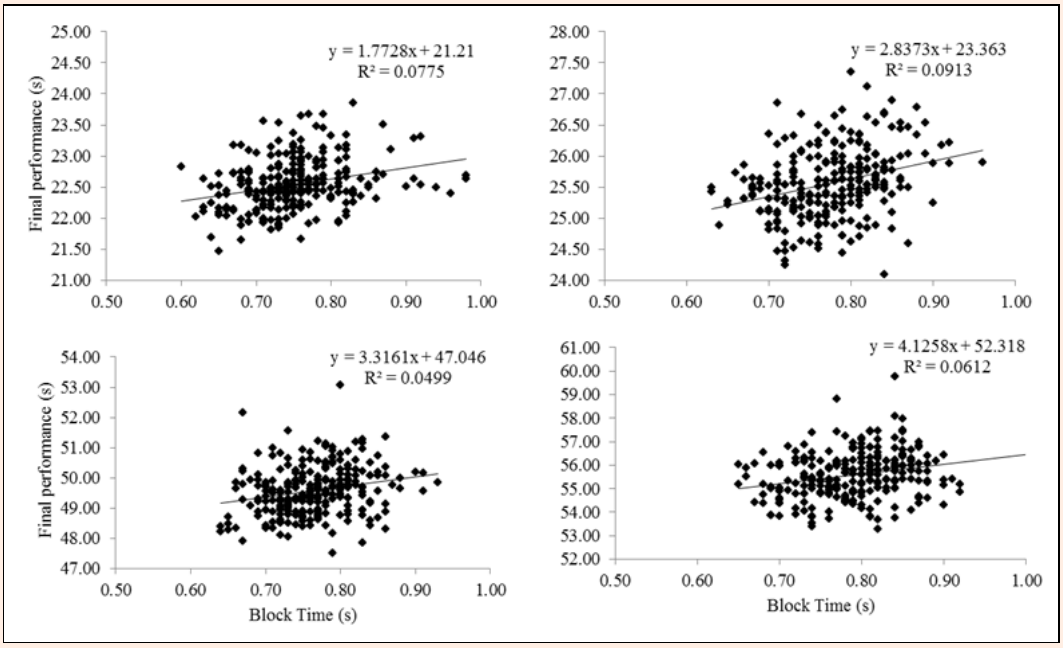

Figure 1. Linear regression of the 50-m freestyle men (top left), 50-m freestyle women (top right), 100-m freestyle men (bottom left), and 100-m freestyle women (bottom right) from the old style blocks.

the potential of conducting specific training to improve the start. It will also be interesting for them to be aware of the effects of the differences between the two types of platform so as to adapt their swimmers' start technique to each. The results can be used by swimmers and coaches as reference times in their start training.

Differences by sex (men vs women), classification groups (medalists, finalists, semi-finalists) and starting block platform (old vs new platforms)

With the old starting platforms, the men had significantly shorter block time than the women in both events: 50-m ($p < 0.001$; $\eta^2 = 0.03$) and 100-m ($p < 0.001$; $\eta^2 = 0.04$) (Table 1). These differences may reflect the importance of lower limb muscle power at the start (West et al., 2011). Moreover, a recent study has shown men to have a shorter auditory stimulus reaction time when large muscle groups are involved (Spierer et al., 2010). Women's reaction time to auditory stimuli also has a greater variability than that of men, the reason perhaps being that sex differences being effects on the brain of the sex hormones present after puberty (Deary and Der, 2005). Indeed, almost all of the difference in block time between men and women can be explained by the lag between stimulus and the onset of muscle contraction (Botwinick and Thompson, 1966). The present results do not concur with those of other studies on swimming which found no such differences, the reason perhaps being that they each only considered a single championship – 1982 Commonwealth Games (Miller et al., 1984), 1996 Olympic Games (Tanner, 2001), and 2000 Olympic Games (Issurin and Verbitsky, 2003). The differences between the sexes were slightly greater with the new starting platforms – in the 50-m ($p < 0.001$; $\eta^2 = 0.10$) and in the 100-m ($p < 0.001$; $\eta^2 = 0.13$) (Table 2). These results confirm the findings of a study in this regard which indicated that men recorded faster times and greater speeds than women in block time (Honda et al., 2010). In general, men were faster in the 50-m ($p < 0.001$; $\eta^2 = 0.04$) and 100-m ($p < 0.001$; $\eta^2 = 0.07$) (Table 3). Again, lower limb muscle power at the start could be the key (West et al., 2011). A recent study has confirmed that the new starting platform allows a greater horizontal force to be generated (Honda et al., 2010), a factor that would further increase these differences, because there are differences in strength lower members between sex (Pappas et al., 2007).

With respect to the classification, with the old platforms the medalists had shorter block times than the semi-finalists (9th-16th) in 50-m ($p = 0.006$). There have been no previous studies in this sense in swimming. In running, however, it has been shown that reducing reaction time could be interpreted as the progressive expenditure of a concentration resource (Collet, 1999), and that it may be effective in sprint races, possibly contributing to victory in the case of a tight finish (Martin and Buoncristiani, 1995). The present results seem to be coherent with these findings in athletics, although one must bear in mind that, for a given distance, e.g., 50-m and 100-m, the time in athletics (100-m) is approximately two times less than in swimming (50-m) (men's 50-m freestyle world record = 20.91 s vs men's 100-m athletics world record = 9.58 s). It would seem logical therefore that the block time is more crucial in athletics. With the new platforms, on the contrary, there were no significant differences between the different classifications (Table 2), despite this platform providing a performance advantage over older models (Biel et al., 2010). Increased use and the popularization of the track start on the part of swimmers in the previous years could be an explanation for these findings. Likewise, the present results thus suggest that the new starting platforms have evened out any differences in the start between the differently classified swimmers or the training process is so developed that the differences between finalists are much reduced nowadays. There hence appears to be a need for further studies to determine how to improve performance with these new starting platforms (Takeda et al., 2012).

With respect to the starting platform, with the new platforms the swimmers had shorter block times than the swimmers with the old platforms in 50-m ($p < 0.001$; $\eta^2 = 0.26$) and 100-m ($p < 0.001$; $\eta^2 = 0.23$) (Table 3). These results show the advantage of this platform over the old one (Biel et al., 2010). Studies in this regard (Biel et al., 2010; Beretić et al., 2012) have found block time differences between the two platforms of between 0.02 and 0.03 s. These values are smaller than those observed in the present study (0.07 and 0.05 s in the 50-m and 100-m, respectively). The difference may reflect the larger size and greater homogeneity (16 finishers) of the present study's sample. These results do nevertheless suggest that swimmers can obtain a clear benefit from using the OSB11 platform. It thus would seem advisable that coaches and swimmers adapt to this new platform and the technique required to optimize performance with it. It is necessary to note here that the rule changes on swimsuit materials and design have been absorbed into the final results together with the reductions in block times, so that the two factors have to be considered together in affecting the swimming performances.

Relationship between block time and final performance

With the old starting platforms, the block time for the men's 50-m freestyle was positively correlated with the final time in the semi-finalist, medalist groups and overall sample (Table 4 and Figure 1). The medalists showed the strongest correlation in this sense (*r*-value greater than that of the other classification groups). A study of 100-m and 200-m breaststroke events relating block time with starting phase times (the first 15 m) suggested that the best swimmers were generally the faster starters (Thompson et al., 2000). In this sense, it is necessary to find the optimal balance between spending enough time on the block to build up a greater impulse and getting off the block as quickly as possible to minimize the time deficit (Vantorre et al., 2010). Indeed, a recent study indicates that swimmers generating higher than average peak forces are more likely to produce a better overall start performance than those who produce forces lower than the average (Slawson et al., 2013). For women, we observed no relationship between block time and final performance in the medalists (1st-3rd) ($p > 0.05$). In contrast, there was such a relationship for the 4th to 16th classifications (finalists and semi-finalists) and in the overall sample (Table 4 and Figure 1). These findings are in part consistent with a study corresponding to the World Swimming Championships (Perth, Australia, 1998) in which the block time in the women's 50-m freestyle was found to be predictive of the measured starting efficiency, and that 21%-50% of the variability of the starting efficiency is explained by the block time variability (Issurin and Verbitsky, 2003). With the new starting platforms, the 9th to 16th placed in men and the medalists in women showed a small inverse relationship with performance (indicated by the negative values of the coefficients). Likewise, the results for both sexes showed a small inverse correlation with performance when the overall sample was analysed (Table 4). The best position of the CM is not clear (Vilas-Boas et al., 2003). When the swimmer is in the set position, the centre of mass (CM) is usually situated farther back than with the old starting platform (Nomura et al., 2010). This could determine a longer block time with the new platforms. Thus the objective in performing a swimming start should be, while the feet are in contact with the starting platform, to move the CM forward as rapidly as possible (Nomura et al., 2010). On the other hand, although recent studies indicate that this new platform reduces block time (Biel et al., 2010; Honda et al., 2010), the present results suggest that there is more relevance in taking time to gain support against the platform, seeking to apply a greater horizontal force, instead of aiming at getting off the starting platform as quickly as possible, especially in women ($r = -0.572$, $p < 0.001$, in medalists).

For the 100-m individual freestyle events with the old starting platforms, the finalist group (4th to 8th) and overall sample presented correlations between block time and final time in men. These findings are not in accordance with the results of previous research studies (Cossor and Mason, 2001; Issurin and Verbitsky, 2003). The differences between winning and losing a race are often so small that the start can be decisive. For example, at the last World Championships in which the old starting platforms were used (Melbourne, 2007), the men's 100-m freestyle bronze medal was won in a time of 48.47 s (block time=0.65 s) with the swimmer in fourth place finishing in a time of 48.51 s (block time=0.72 s), so that the difference in block time is enough to have determined the final result. This may be explained by the ratio of RT to total race time, with one or two hundredths of a second potentially being important in the final result (Collet, 1999). In the 100-m individual freestyle events in women, the correlations observed were for the semi-finalists (9th-16th) ($r = 0.241$; $p < 0.001$) and overall sample ($R^2 = 0.033$; $p < 0.001$), and even then the correlations were small in the sense defined above. This could indicate that the second lap of the 100-m is the more closely related with the final performance (Robertson et al., 2009) or that the block time is less important in this event. No account was taken, however, of the different starting techniques (grab or track start) on the old platforms. Probably, the positive correlation between BT and final performance with the old starting block could be explained by the increasing population of swimmers using the track start. Indeed, some workers report finding differences in block time between the two starting techniques (grab or track start) on the old platforms (Issurin and Verbitsky, 2003; Vilas-Boas et al., 2003), although others report finding no such differences (Blanksby et al., 2002). Notwithstanding whether or not there were such differences in block time between the two techniques, no such difference was maintained in the total start time (at 7 m or 15 m) (Vilas-

Boas et al., 2003; Welcher et al., 2008). With the new starting platforms, the only correlation of block time with final performance was in men semi-finalists (9th to 16th) (Table 4). As was the case in the 50-m event, the relationship was inverse (r = -0.307, p = 0.006). A recent study to the effect indicates that, with the new platforms, there is increasing distance of the placement of the back foot (back plate position) and rear foot take-off times were significantly longer in the ascending order (0.29, 0.44 and 0.59 m) (Takeda et al., 2012). Probably, the swimmers are seeking to generate a greater horizontal take-off force on the platform at the expense of their block time. A recent study indicated to leaning further towards the rear of the block resulted in higher velocity off the block however, the block time increase to respect other positions (Honda et al., 2012). It seems that the timing of rear leg drive is associated with changes in the mean velocities until take-off (Takeda et al., 2012). In this sense, there appears to be some controversy since diverse studies indicate that take-off velocities with the new platform are similar to those reported for the conventional starting platforms (Nomura et al., 2010; Takeda et al., 2012), while another study finds greater speeds of the swimmer with the new platform (Honda et al., 2010). It therefore seems necessary to investigate why the use of a back plate did not create an advantage in terms of start performance, and why the changes in velocity until take-off differ for different inclinations and positions of the back plate (Takeda et al., 2012). In this sense, a recent study said that for the best starts, peak horizontal force production occurred with an obtuse knee angle of 100-110° and peak vertical force at a rear knee angle of 80-90° (Slawson et al., 2012). Lastly, it has to be emphasized that the negative or non-significant correlation between block time and final performance with the new starting block might be because most of the swimmers used a track start technique. Also, in starts with the old platform, equilibrium was broken with the arms, while, with the new platform, it is broken by applying force from the leg which is farther back.

Limitations

This study has some limitations. First, block time is the combination of reaction time plus movement time, so that there was no way to distinguish between their relative importances. Second, no analysis was made of the set-up of the position and inclination of the new starting platforms used by each of the swimmers. This could have influenced both the block time and the start phase in general (take-off angle, horizontal take-off velocity, vertical take-off velocity, flight distance, inter alia) (Slawson et al., 2011; 2012; 2013; Takeda et al., 2012).

Conclusion

In general, one can conclude that the men had shorter block time in their starts than the women in both events (50-m and 100-m freestyle) and with both platforms. Likewise, the swimmers had shorter block times in their starts with new starting platform than with the old platform in both events. Also, for 50-m event the medalists (1st-3rd placed) had shorter block time than the semi-finalists (9th-16th placed) with the old starting platforms. While the block time was related for the final performance in the men's 50-m event with the old starting platform, this was not the case for the 100-m event for the women (both events). In contrast, with the new starting platforms, block time was only related in the women's 50-m event, but with the relationship being inverse. This suggests that with this platform it is preferable to achieve a good impulse than to try to get off the platform as quickly as possible. In particular, therefore, specific training with the new platform should be considered in order to improve performance.

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References

Arellano, R., Brown, P., Cappaert, J. and Nelson, R.C. (1994) Analysis of 50-, 100-, and 200-m freestyle swimmers at the 1992 Olympic Games. *Journal of Applied Biomechanics* **10,** 189-199.

Balilionis, G., Nepocatych, S., Ellis, C.M., Richardson, M.T., Neggers, Y.H. and Bishop, P.A. (2012) Effects of different types of warm-up on swimming performance, reaction time, and dive distance. *The Journal of Strength & Conditioning Research* **26(12)**, 3297-3303.

Beretić, I., Durović, M. and Okičić, T. (2012) Influence of the black plate on kinematical starting parameter changes in elite male serbian swimmers. *Facta Universitatis. Physical Education and Sport* **10(2),** 135-140.

Biel, K., Fischer, S. and Kibele, A. (2010) Kinematic analysis of take-off performance in elite swimmers: New OSB11 versus traditional starting block. In: *Biomechanics and Medicine in Swimming XI.* Eds. Kjendlie, P., Stallman, R.K. and Cabri, J. Oslo, Norwegian School of Sport Science. 91.

Bishop, D.C., Smith, R.J., Smith, M.F. and Rigby, H.E. (2009) Effect of plyometric training on swimming block start performance in adolescents. *The Journal of Strength & Conditioning Research* **23,** 213-214.

Bland, J.M. and Altman, D.G. (1995) Multiple significance tests: the Bonferroni method. *British Medical Journal* **310(6973),** 170.

Blanksby, B., Nicholson, L. and Elliott, B. (2002) Biomechanical analysis of the grab, track, and handle swimming starts: An intervention study. *Sports Biomechanics* **1(1),** 11-24.

Botwinick, J. and Thompson, L.W. (1966) Components of reaction time in relation to age and sex. *Journal of Genetic Psychology* **108,** 175-183.

Breed, R.V. and Young, W.B. (2003. The effect of a resistance training programme on the grab, track and swing starts in swimming. *Journal of Sports Science* **21(3),** 213-220.

Brown, A. M., Kenwell, Z. R., Maraj, B. K. and Collins, D. F. (2008) "Go" signal intensity influences the sprint start. *Medicine & Science in Sports & Exercise* **40(6),** 1142-1148.

Buckolz, E. (1980) Sprint start reaction time: should one attend to the input or the output or does it matter? *Canadian Journal of Applied Sport Sciences* **5(3),** 146-152.

Buckolz, E. and Vigarhe, B. (1987) Sprint start reaction time: on the advisability of sensory vs motor sets. *Canadian Journal of Sport Sciences* **12(1),** 51-53.

Cohen, L. (1988) Statistical power analysis for the behavioural sciences. Hillsdale: Lawrence Erlbaum Associates.

Collet, C. (1999) Strategic aspects of reaction time in world-class sprinters. *Perceptual & Motor Skills* **88(1),** 65-75.

Cossor, J.M. and Mason, B.R. (2001) Swim start performances at the Sydney 2000 Olympic Games. In: *XIX International Symposium on Biomechanics in Sports ISBS*. Eds: Blackwell, J.R. and Sanders, R.H. San Francisco, International Society of Biomechanics in Sport. 70-73.

Costa, J., Marinho, D.A., Reis, V., Silva, A.J., Marques, M., Bragada, J. A. and Barbosa, T.M. (2010) Tracking the performance of world-ranked swimmers. *Journal of Sports Science and Medicine* **9,** 411-417.

Deary, I.J. and Der, G. (2005) Reaction time, age and cognitive ability: Longitudinal findings from age 16 to 63 years in representative population samples. *Aging Neuroscience and Cognition* **12,** 187-215.

Escalante, Y., Saavedra, J.M., Mansilla, M. and Tella, V. (2011) Discriminatory power of water polo game-related statistics in 2008 Olympic Games. *Journal of Sports Science* **29,** 291-298.

Escalante, Y., Saavedra, J.M., Tella, V., Mansilla, M., García-Hermoso, A. and Dominguez, A.M. (2012) Water polo game-related statistics in Women's International Championships: Differences and discriminatory power. *Journal of Sports Science and Medicine* **11,** 475-482.

Escalante, Y., Saavedra, J.M., Tella, V., Mansilla, M., García-Hermoso, A. and Dominguez, A.M. (2013) Water polo game-related statistics in Women's International Championships: Differences and discriminatory power. *Journal of Strength and Conditioning Research* **27(4),** 893-901.

Galbraith, H., Scurr, J., Hencken, C., Wood, L. and Graham-Smith, P. (2008) Biomechanical comparison of the track start and the modified one-handed track start in competitive swimming: an intervention study. *Journal of Applied Biomechanics* **24(4),** 307-315.

Hay, J.G. (1986) Swimming. In: *Starting, Stroking & Turning (A Compilation of Research on the Biomechanics of Swimming, The University of Iowa, 1983-86)*. Ed. Hay, J.G. Iowa, Biomechanics Laboratory, Department of Exercise Science. 1-51.

Honda, K.E., Sinclair, P.J., Mason, B.R. and Pease, D.L. (2010) A Biomechanical comparison of elite swimmers start performance using the traditional track start and the new kick start'. In: *Biomechanics and Medicine in Swimming XI*. Eds: Kjendlie, P., Stallman, R.K. and Cabri, J. Oslo, Norwegian School of Sport Science. 94-96.

Honda, K.E., Sinclair, P.J., Mason, B.R. and Pease, D.L. (2012) The effect of starting position on elite swim start performance using and angled kick plate. In: *Proceedings 30th Annual Conference of Biomechanics in Sports*. Melbourne. Eds: Bradshaw, J., Burnett, A. and Hume, P.A. 72-75.

Issurin V. and Verbitsky, O. (2003) Track start versus grab start: evidence from the Sydney Olympic Games. In: *Swimming Science IX, 2003*. Ed: Chatard, J.C. Saint Etienne, University of Saint Etienne. 213-217.

Maglischo, E.W. (2003) *Swimming fastest*. Champaign, Human Kinetics.

Martin, E. and Buoncristiani, I.F. (1995) Influence of reaction time on athletic performance. *New Studies in Athletics* **10,** 67-69.

Mason, B. and Cossor, J. (2000) What can we learn from competition analysis at the 1999 Pan Pacific Swimming Championships? In: *Proceedings of XVIII Symposium on Biomechanics in Sports: Applied Program: Application of Biomechanical Study in Swimming*. Eds: Sanders, R. and Hong, Y. Hong Kong: Department of Sports Science and Physical Education the Chinese University of Hong Kong. 75-82.

Miller, J.A., Hay, J.G. and Wilson, B.D. (1984) Starting techniques of elite swimmers. *Journal of Sports Sciences* **2,** 213-223.

Muehlbauer, T., Schindler, C. and Widmer, A. (2010) Pacing pattern and performance during the 2008 Olympic rowing regatta. *European Journal of Sport Science* **10(5),** 291-296.

Nomura, T., Takeda, T. and Takagi, H. (2010) Influences of the back plate on competitive swimming starting motion in particular projection skill. In: *Biomechanics and Medicine in Swimming XI*. Eds: Kjendlie, P., Stallman, R. K. and Cabri, J. Oslo, Norwegian School of Sport Science. 137-137.

Pappas, E., Hagins, M., Sheikhzadeh, A., Nordin, M. and Rose, D. (2007) Biomechanical differences between unilateral and bilateral landings from a jump: gender differences. *Clinical Journal of Sport Medicine* **17,** 263–268.

Robertson, E., Pyne, D., Hopkins, W. and Anson, J. (2009) Analysis of lap times in international swimming competitions. *Journal of Sports Science* **27,** 387-395.

Saavedra, J.M., Escalante, Y., García-Hermoso, A., Arellano, R. and Navarro, F. (2012) A twelve-year analysis of pacing strategies in 200 m and 400 m individual medley in international swimming competitions. *Journal of Strength and Conditioning Research* **26(12),** 3289-3296.

Sanders, R. (2002) New analysis procedures for giving feedback to swimming coaches and swimmers. In: *Proceedings of XX ISBS – Swimming, Applied Program*. Eds: Gianikellis, K.E., Mason, B. R., Toussaint, H. M., Arellano, R. and Sanders, R. Cáceres, University of Extremadura. 1-14.

Seifert, L., Vantorre, J. and Chollet, D. (2007) Biomechanical analysis of the breaststroke start. *International Journal Sports Medicine* **28(11),** 970-976.

Seifert, L., Vantorre, J., Lemaitre, F., Chollet, D., Toussaint, H.M. and Vilas-Boas, J.P. (2010). Different profiles of the aerial start phase in front crawl. *The Journal of Strength & Conditioning Research* **24(2),** 507-516.

Slawson, S.E., Chakravorti, N., Conway, P.P., Cossor, J. and West, A.A. (2012) The Effect of Knee Angle on Force Production, in Swimming Starts, using the OSB11 Block. *Procedia Engineering* **34**, 801-806.

Slawson, S.E., Conway, P.P., Cossor, J., Chakravorti, N., Le-Sage, T. and West, A.A. (2011) The effect of start block configuration and swimmer kinematics on starting performance in elite swimmers using the Omega OSB11 block. *Procedia Engineering* **13,** 141-147.

Slawson, S.E., Conway, P.P., Cossor, J., Chakravorti, N. and West, A.A. (2013) The categorisation of swimming start performance with reference to force generation on the main block and footrest components of the Omega OSB11 start blocks. *Journal of Sports Science* **31(5),** 468-478.

Spierer, D.K., Petersen, R.A., Duffy, K., Corcoran, B.M. and Rawls-Martin, T. (2010) Gender influence on response time to sensory stimuli. *The Journal of Strength & Conditioning Research* **24(4),** 957-963.

Takeda, T., Takagi, H. and Tsubakimoto, S. (2012) Effect of inclination and position of new swimming starting block's back plate on track-start performance. *Sports Biomechanics* **11(3),** 370-381.

Tanner, D. (2001) Sprint performance times related to block time in Olympic swimmers. *Journal of Swimming Research* **15,** 12-19.

Thompson, K.G., Haljand, R. and MacLaren, D.P. (2000) An analysis of selected kinematic variables in national and elite male and female 100-m and 200-m breaststroke swimmers. *Journal of Sports Science* **18,** 421-431.

Vantorre, J., Seifert, L., Fernandes, R.J., Boas, J.P. and Chollet, D. (2010) Comparison of grab start between elite and trained swimmers. *International Journal Sports Medicine* **31(12),** 887-893.

Vilas-Boas, J.P., Cruz, M.J., Sousa, F., Conceiçao, F., Fernandes, R. and Carvalho, J. (2003) Biomechanical analysis of ventral swimming starts: comparison of the grab start with two track start techniques. In: *Swimming Science IX*. Ed: Chatard, J.C. Saint Etienne, University of Saint Etienne. 249-253.

Welcher, R.L., Hinrichs, R.N. and George, T.R. (2008) Front- or rear-weighted track start or grab start: which is the best for female swimmers? *Sports Biomechanics* **7(1),** 100-113.

West, D.J., Owen, N.J., Cunningham, D.J., Cook, C.J. and Kilduff, L P. (2011) Strength and power predictors of swimming starts in international sprint swimmers. *The Journal of Strength & Conditioning Research* **25(4),** 950-955.

Key points

- The men had shorter block times than the women in both events and with both platforms.
- For both distances, the swimmers had shorter block times in their starts from the new starting platform with a back plate than with the old platform.
- For the 50-m event with the old starting platform, the medalists had shorter block times than the semi-finalists.
- The new starting platform block time was only determinant in the women's 50-m event.
- In order to improve performance, specific training with the new platform with a back plate should be considered.

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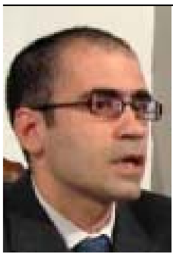

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