

# The backstroke starting variants performed under the current swimming rules and block configuration

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## Abstract

*Backstroke start has evolved since last 10 years due to modifications on international rules and block configuration; however, researchers have not yet attempted to verify the combined effects of these changes on the backstroke start technique. Therefore, this study aimed to identify the backstroke starting variants performed at elite swimming events considering the effects of the current FINA rules and the starting block handgrip actualizations. Video images from individual backstroke events recorded during 2012 Olympic Games and 2013 Swimming World Championships were analyzed from official FINA's videos. Frequency analysis was calculated to verify the starting variants distribution by gender, event and classification. Considering 100 and 200 m backstroke heats, semi-finals and finals, male and female swimmers adopted four and six different starting variants, respectively. Analyzing only the semi-finals and finals, males performed two variants at 50 and 100 m and three variants at 200 m event, respectively, while females adopted three variants at 50 and 200 m and four variants at 100 m event, respectively. Independently of the gender, event and classification, swimmers frequently performed one variant with feet parallel and partially emerged and hands grasping the highest horizontal handgrip and the other one with feet parallel and partially emerged and hands grasping the vertical handgrip. In order to complement these findings, further studies are required to provide coaches and swimmers with biomechanical evidences of the different backstroke starting variants.*

## Introduction

Researchers have been interested since long, in targeting swimming race analysis rather than only simple split times. According to Hay and Guimarães (1983) the swimming race time can be divided into the starting, stroking and turning sections. Starting performance, usually defined as the period between the starting signal and the first 15 m mark is crucial in short (Arellano, et al., 2003, Cossor and Mason, 2001, Ikuta, et al., 2001, Maglischo, 2003, Thanopoulos, et al., 2012) and middle distance swimming events (Girold, et al., 2001, Miller, et al., 1984). In fact, the difference between the best and worst starters at elite swimming level is likely to achieve 0.5 s, which may determine the final

classifications (Mason, et al., 2012, Seifert, et al., 2009, Vilas-Boas and Fernandes, 2003, Wilson and Howard, 1983). For example, less than 0.5 s has separated the second place from the winner at men's 50, 100 and 200 m backstroke at Barcelona 2013 Long Course Swimming World Championships.

Swimming competitions hold starting techniques for ventral and dorsal events. Conversely, few studies have been drawing their attention towards the backstroke start technique (de Jesus, et al., 2013, Hohmann, et al., 2008, Theut and Jensen, 2006) opposing lots of others which have analyzed the mechanics of different ventral starting techniques (e.g. Hanin, et al., 2004, Vantorre, et al., 2010a, 2010b). This lack might be explained by the higher number of swimming events beginning from a standing position on the starting block rather than in water (Theut and Jensen, 2006) and by the previous lower number of options and controversy about the backstroke starting variants performed under the Fédération Internationale de Natation (FINA) old rules (Vilas-Boas and Fernandes, 2003). From the available data regarding the backstroke start, almost all studies are outdated or limited as the international swimming rules have changed and most of the starting variants analyzed were deemed to be illegal (Vantorre, et al., 2010a). To date, only de Jesus et al. (2011a; 2011b; 2013), Nguyen et al., (2014) and Takeda et al., (2014) have conducted studies under FINA's current backstroke starting rules (FINA, SW 6.1), considering the different feet positioning and the respective effects on biomechanical parameters.

No study has yet considered the current starting block update in backstroke starting analysis. However, the combination of different upper and lower limbs positioning might substantially affect the backstroke starting performance, highlighting the need for further investigation. An overview of the backstroke starting technique considering current FINA rules and block facilities is imperative for the purposes of highlighting the most popular starting variants performed and future research stimulation. In fact, Green et al. (1987) had already mentioned that as soon as this skill is successfully approved by swimmers, biomechanists will carry on a careful review. Therefore, it was necessary to identify the starting variants which have been performed by elite backstroke swimmers after the FINA's rule changes and the implementation of the current starting block configuration. It was hypothesized that most of the elite male and female swimmers would perform starting variants with the feet positioned entirely or partially above the water level and hands grasping on the highest horizontal or vertical handgrip to uplift the body as high as possible out of the water during the set positioning.

## **Methods**

### Participants

The sample has comprised swimmers of both genders who have competed at 100 and 200 m backstroke heats, semi-finals and finals at London 2012 Olympic Games and at 50, 100 and 200 m backstroke semi-finals and finals at Barcelona

2013 Swimming World Long Course Championships. Swimmers competing more than once at the classification series (i.e., heats, semi-finals and finals) got in the sample procedure only once, since the variant performed was unchanged. Only swimmers who have competed in lanes five to eight were observed due to camera view obstruction.

Mean ( $\pm$  SD), minimum and maximum values of body mass, height, age, and time obtained at each scrutinized event for male and female swimmers at the three individual backstroke competitive distances are presented in Table 1. The 100 and 200 m backstroke data for males and females was calculated including 2012 Olympic Games and 2013 Swimming World Championships participants, since the 50 m backstroke was not included as an Olympic event. Personal and anthropometric data were retrieved from web portals, particularly from London 2012 Olympic Games and FINA swimmers' biographies. Performance data at each event and distance for male and female swimmers was taken from the event organizer official website.

Table 1. Mean ( $\pm$ SD), minimum and maximum values of body mass, height, age and time for male and female swimmers at each individual backstroke competitive distance. The 100 and 200 m backstroke data for males and females were calculated including the Olympic Games and Swimming World Championships participants.

		Body mass (Kg)		Height (m)		Age (yr)		Time (s)	
		Male (n=8)	Female (n=8)	Male (n=8)	Female (n=8)	Male (n=10)	Female (n=10)	Male (n=11)	Female (n=10)
50m	Mean	90.3	62.5	1.94	1.74	26.1	22.2	24.84	28.07
	SD	3.4	4.4	0.07	0.02	3.4	3.6	0.03	0.04
	Minimum	73.0	59.0	1.84	1.70	21.0	18.0	24.39	27.29
	Maximum	113.0	69.0	2.03	1.76	31.0	29.0	25.28	28.61
100m	Mean	78.9	66.6	1.87	1.77	23.8	22.4	54.42	61.00
	SD	7.2	6.9	0.07	0.07	3.2	3.4	1.04	2.14
	Minimum	62.0	57.0	1.77	1.60	17.0	16.0	52.97	58.23
	Maximum	95.0	85.0	2.00	1.87	29.0	29.0	57.94	68.19
200m	Mean	77.2	64.8	1.86	1.75	22.7	21.4	118.14	130.49
	SD	8.0	4.9	0.06	0.05	3.8	3.3	1.90	3.17
	Minimum	62.0	57.0	1.73	1.64	17.0	14.0	113.94	124.06
	Maximum	91.0	76.0	2.05	1.85	36.0	29.0	122.12	138.60

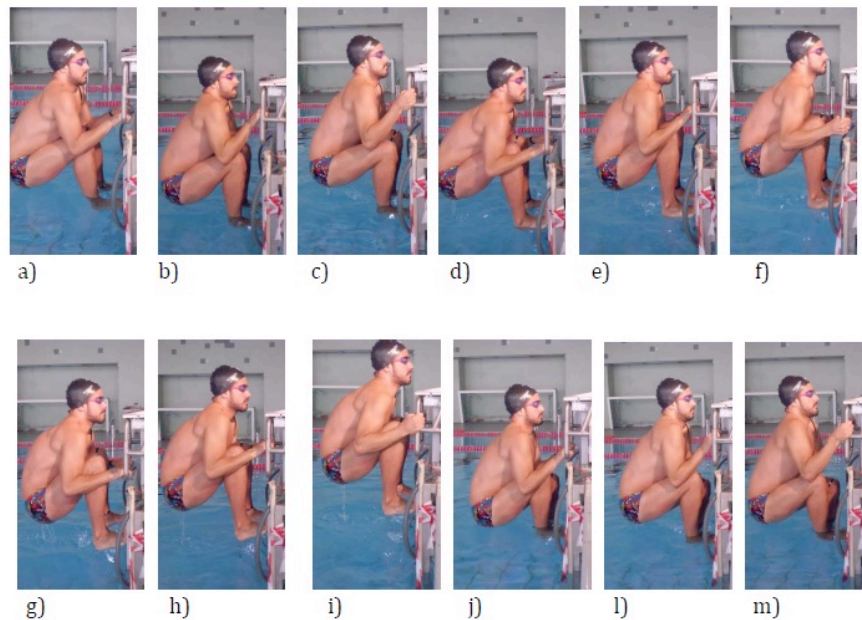
Data collection

Backstroke starts performed at individual 50, 100 and 200 m events were analyzed from an aerial video camera (FINA official video images). Missing data

were noted in the Olympic Games videos at 5<sup>th</sup> women’s 100 m backstroke heat, 1<sup>st</sup> women’s 200 m backstroke heat and lanes six, seven and eight of 4<sup>th</sup> men’s 200 m backstroke heat.

Data analysis

Backstroke starting technique performed by each swimmer was classified according to different combinations of upper and lower limbs positioning at the command of “take-your marks”. These combinations were defined based on the current FINA’s backstroke starting rules (FINA, 2013), the starting block configuration (Omega, OSB11, Corgémont, Swiss Timing Ltd.) and on literature (Figure 1). None of the swimmers who had been analyzed at Barcelona 2013 Swimming World Championships used the recently authorized ledge device (FINA, 2013).



**Figure 1.** The backstroke starting variants, characterized by the combination of different upper and lower limbs positioning. Feet immersed and lowest and highest horizontal, and vertical, handgrip (Panels a, b and c, respectively). Feet partially emerged and lowest and highest horizontal, and vertical, handgrip (Panels d, e and f, respectively). Feet entirely emerged and lowest and highest horizontal and vertical, handgrip (Panels g, h and i, respectively). Feet staggered and lowest and highest horizontal, and vertical, handgrip (Panels j, l and m, respectively).

Statistical Procedures

Frequency analyses were conducted aiming to verify the starting variants distribution by gender, swimming events (50, 100 and 200 m) and classifications (heats, semi-finals and finals). The 1<sup>st</sup> frequency analysis calculated for male and females and for 100 and 200 m backstroke included swimmers who participated at heats, semi-finals and finals at London 2012 Olympic Games and at semi-finals and finals at 2013 Barcelona Swimming World Championships. To analyze the starting distributions among the most proficient backstroke Olympic and World

Championships swimmers, the 2<sup>nd</sup> frequency analysis for both genders has included only swimmers from the semi-finals and finals of 50 m backstroke at Barcelona 2013 Swimming World Championships and 100 and 200 m backstroke at both competitive events.

To test the intra and inter observer reliability, a second video analysis was conducted after 15 days from the 1<sup>st</sup> observation, being observed both competition overall heats, semi-finals and finals. The value obtained (98.4%) corresponds to a high intra and inter observer reliability (Van Der Mars, 1989). The statistical procedures were conducted through IBM®SPSS® Statistics system 20.

**Results**

From the overall combinations of upper and lower limbs positioning (cf. Figure 1) seven starting variants were observed (Figure 1, Panels b, c, d, e, f, i, j). Considering 100 and 200 m backstroke heats, semi-finals and finals at 2012 Olympic Games and semi-final and finals at 2013 Swimming World Championships, male swimmers adopted four different backstroke starting variants (Table 2), with the most frequent one (with feet positioned parallel and partially emerged and hands grasping on the vertical handgrip, Figure 1, Panel f) found on the 100 m event. Conversely, in 200 m male backstroke, swimmers often used the variant with feet parallel and partially emerged and hands grasping on the highest horizontal handgrip (Figure 1, Panel e). In the same events, female swimmers used six different starting variants (cf. Table 2). The starting variant with feet parallel and partially emerged and hands positioned on the highest horizontal handgrip (Figure 1, Panel e) was the most common used at 100 and 200 m backstroke.

Table 2. Absolute and relative frequency distribution of the backstroke starting variants performed by male and female swimmers at 100 and 200 m backstroke heats, semi-finals and finals of 2012 Olympic Games and at semi-finals and finals of 2013 Swimming World Championships.

	Variants	100m		200m		
		Count	% of variants	Variants	Count	% of variants
Male	1	1	2.8%	3	2	7.4%
	5	17	47.2%	5	15	55.6%
	6	18	50.0%	6	10	37.0%
Female	2	1	2.9%	2	1	3.2%
	4	4	11.4%	3	1	3.2%
	5	16	45.7%	5	18	58.1%
	6	13	37.1%	6	11	35.5%
	7	1	2.9%			

The frequency analysis on the men’s semi-finalists and finalists at 50 m backstroke at 2013 Swimming World Championship and at 100, 200 m backstroke in both competitions (Table 3), showed two variants for 50 and 100 m and three variants for 200 m event commonly used by backstroke swimmers. The starting variant performed with feet parallel and partially emerged and hands grasped on the highest horizontal handgrip (Figure 1, Panel e) was the most adopted on 50 and 200 m backstroke, while the variant performed with feet parallel and partially emerged and hands positioned on the vertical handgrip (Figure 1, Panel f) was the most used on 100 m backstroke event. In the same events, female swimmers displayed three variants for 50 and 200 m and four variants for 100 m event, respectively (Table 3). Female backstrokers performing the 50 m event rather adopted the starting variant with feet parallel and partially emerged and hands grasping on the vertical handgrip (Figure 1, Panel f). Regarding 100 and 200 m backstroke, swimmers commonly performed the variant with feet parallel and partially emerged and hands grasping on the highest horizontal handgrip (Figure 1, Panel e).

Table 3. Absolute and relative frequency distribution of the backstroke starting variants performed by male and female swimmers at 50, 100 and 200 m backstroke (semi-finals and finals) at London 2012 Olympic Games and Barcelona 2013 Swimming World Championships.

	50m			100m			200m		
	Variants	Count	% of variants	Variants	Count	% of variants	Variants	Count	% of variants
Male	5	6	54.5%	5	9	42.9%	3	1	6.3%
	6	5	45.5%	6	12	57.1%	5	8	50.0%
							6	7	43.8%
Female	4	2	20.0%	2	1	2.7%	2	1	5.0%
	5	3	30.0%	4	2	10.0%	5	11	55.0%
	6	5	50.0%	5	9	45.0%	6	8	40.0%
				6	8	40.0%			

Note: 1=Entirely emerged and vertical handgrip; 2=Entirely immersed and vertical handgrip; 3=Entirely immersed and highest horizontal handgrip; 4=Partially emerged and lowest horizontal handgrip; 5=Partially emerged and highest horizontal handgrip; 6=Partially emerged and vertical handgrip.

**Discussion**

The backstroke swimming start has been increasingly evolving after the last FINA’s rule changes and starting block configuration, with swimmers being currently allowed to perform several starting variants (Figure 1). Hence, considering the obvious importance of the starting phase on the overall swimming race time (Mason, et al., 2012, Vilas-Boas and Fernandes, 2003) and

that most of the studies have dealt with obsolete backstroke starting rules (Arellano, et al., 2003, Cossor and Mason, 2001, Girold, et al., 2001, Ikuta, et al., 2001, Miller, et al., 1984, Stratten, 1970, Theut and Jensen, 2006, Wilson and Howard, 1983) or have not yet considered the starting block actualizations (de Jesus, et al., 2013, Hohmann, et al., 2008, Takeda, et al., 2014), this study is original and pertinent once it describes the backstroke starting technique and respective variants adopted at individual elite events. Nevertheless, a better understanding on the competition data may be crucial to establish specific training programs and to impart new researching areas. Our findings revealed that independently of gender, event and classification, backstroke swimmers performed mainly two starting variants: one, with feet parallel and partially emerged and hands grasping on the highest horizontal handgrip (Figure 1, Panel e), and other with feet parallel and partially emerged and hands positioned on the vertical handgrip (Figure 1, Panel f). These results partially agree with our hypothesis.

Considering men's 100 and 200 m backstroke heats, semi-finals and finals, swimmers have adopted a small starting variants number rather than females, probably due to the previous mentioned gender effects (Takeda, et al., 2014). At 100 m backstroke, most of the swimmers have chosen the variant with feet positioned parallel and partially emerged and hands grasping on the vertical handgrips (Figure 1, Panel f). In opposition, 200 m swimmers have performed often the feet positioned parallel and partially emerged and hands grasping on the highest horizontal handgrip (Figure 1, Panel e). Since a previous backstroke starting research mentioned that the Biceps Brachii is mainly activated during the hands-off phase (de Jesus, et al., 2011b), the forearm positioned laterally potentiates this muscle action to pull the swimmer's body out of water in a crouched position at the "take-your marks" command. Swimmers in a high setting positioning and closer to the pool wall may generate great vertical force during the hands-off and take-off phases (de Jesus, et al., 2011a, Maglischo, 2003), and, consequently, a clearer flight and water immersion (de Jesus, et al., 2011a, de Jesus, et al., 2013, Seifert, et al., 2009, Takeda, et al., 2014). New kinematic, kinetic and EMG studies would be useful to verify in detail the influence of different handgrips when the backstroke start is performed with feet parallel and partially emerged.

In the same events, female swimmers performed, in total, six different starting variants. The higher quantity of starting variants carried out by female swimmers might be explained mainly due to strength differences, compared to males. In fact, de Jesus et al. (2011a, 2011b) and Hohmann et al. (2008) have mentioned the essential role played by the upper limb muscles to fix the body in a high starting position close to the wall. Despite these results, the starting variant with feet parallel and partially above the water surface with the hands grasping on the highest horizontal handgrip (Figure 1, Panel e) was the most used by female swimmers. It could be speculated that female swimmers

welcomed best the horizontal positioning on the highest handgrip to sufficiently raise the centre of mass and achieve a better support, consequently generating a meaningful magnitude of upper limbs propulsive force, as previously suggested by Maglischo (2003), but not confirmed by de Jesus et al. (2011a, 2013). Further studies are needed to identify if swimmers' hands positioned on the highest horizontal handgrip increase the upper limbs vertical reaction force contribution on the resultant impulse during the upward thrust from the swimming pool wall.

Analyzing the starting variants distribution including only the semi-finalists and finalists of 100 and 200 m backstroke in both competitive events, male and female swimmers seem to adopt a more reduced variants number. It might indicate that some starting variants present common biomechanical advantages, which should be analyzed in detail. The starting variants most frequently used by male semi-finalists and finalists at 50, 100 and 200 m backstroke were the feet partially emerged and hands grasping on the highest horizontal (Figure 1, Panel e) and vertical handgrips (Figure 1, Panel f). The 50 and 200 m backstroke swimmers rather performed the variant with feet partially emerged and hands grasping on the highest horizontal handgrip, while 100 m swimmers adopted similar feet positioning, but with the hands vertically positioned. These findings highlight the need of further investigation to understand the possible mechanical advantages that starting variants performed with feet partially above the water level might generate over the feet entirely immersed or emerged. In addition, since Miller et al. (1984) have recommended swimmers to use similar starting variants at short and middle distance events, it might be speculated that elite backstrokers are able to perform with excellence the backstroke start with feet parallel and partially above the water level independently of the highest horizontal or vertical handgrip.

Considering the same classifications, female swimmers participants of 50, 100 and 200 m backstroke events commonly used similar starting variants as males, particularly the feet parallel and partially emerged and hands grasping on the highest horizontal and vertical handgrips. These findings suggest that elite swimmers have prioritized less body water contact during the setting positioning, with less water resistance needed to be moved through the push off the wall (de Jesus, et al., 2011a, Maglischo, 2003). As also observed for male swimmers, females used different handgrips positioning depending on the distance. At 50 m backstroke swimmers adopted the hands positioned vertically, while at 100 and 200 m events, females used the hands positioned at the highest horizontal handgrips. According to Miller et al. (1984) swimmers participants at shorter distances may use a starting variant which allows them to remain in the air after take-off for longer than those in longer events. Despite researchers have provided important findings about the influence of different lower limbs positioning at ventral (e.g. Thanopoulos, et al., 2012, Theut and Jensen, 2006) and dorsal (de Jesus, et al., 2011a, 2011b, de Jesus, et al., 2013, Stratten, 1970) starts, this study highlights the need for further analysis regarding the role



played by upper limbs at backstroke start, since it may represent an advantage of hundredths of a second at final race time.

## Conclusion

This study is a first step to convey the implications of the current FINA backstroke starting rules combined to the recent starting block configuration on the backstroke starting technique. Considering genders, competitions and classifications, seven out of twelve possible different starting variants were observed. The most common variants performed by male and female backstroke swimmers, independently of the swimming events and classifications were: with feet parallel and partially emerged and hands grasping on the highest horizontal handgrip, and with feet parallel and partially emerged and hands grasping on the vertical handgrip. These two variants collectively accounted for an average 91.3% of all the male and female participants in the study. Notwithstanding the originality and relevance of the current data, it is acknowledged that the camera view obstruction represents a significant limitation, since only images of four lanes in each swimming event were analyzed.

Future studies should analyze biomechanically each backstroke starting variant advantages and disadvantages, clarifying how swimmers should perform each one to achieve better performance. It is recommended that coaches and swimmers should spend time in adapting to current FINA rules and new block facilities previously to decision about which backstroke starting variant to be adopted.

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