

COMPARATIVE ANALYSIS OF TEMPORAL PARAMETERS OF DIFFERENT TECHNIQUES OF THE FREESTYLE FLIP TURN

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This study aimed to describe and compare temporal parameters of four different turning techniques of Freestyle swimming flip turn. 17 national level swimmers participated in this study. After practicing sessions, the swimmers performed three times each of the four analyzed techniques. Performance was videotaped using six video cameras and the analyzed variables were: rolling time, wall contact time, pushing time, gliding time and total turn time. No differences were found between the techniques for any variable. Apparently, the choice of the technique can be made accordingly to the swimmer's subjective preference, or based on the objective performance differences casuistically sustained. However, future studies are needed and additional performance indicators should be analyzed to provide a better understating regarding the different techniques.

KEYWORDS: biomechanics, swimming, turning, performance.

INTRODUCTION: The flip turn in swimming is a considerably complex action. Therefore, it is a difficult movement to be analyzed. During recent years, few studies have been carried out to investigate this race phase (Daniel et al. 2003; Prins & Patz, 2006; Pereira et al., 2008; Araujo et al., 2010), although the improvement of turning technique could reduce race times by, at least, 0.20 s per lap (Maglischo, 2003).

The technical execution of the flip turn has changed over the years and recently a wide variability of styles can be observed during the Freestyle events in high-level competitions (Pereira et al., 2006). According to the body position assumed by the swimmer during the rolling, wall touch, pushing and gliding phases, the flip turn can be performed in different ways (Hay, 1981; Araujo et al. 2003; Maglischo, 2003; Pereira et al., 2006).

Hajjand (1998) and Maglischo (2003) indicated that variations on the technique, as different body positions during the rolling phase and different strategies used by the swimmers when pushing the wall, could directly influence the performance. However, there are no data on literature regarding the comparison between different turning techniques.

On the basis of these considerations, the aim of this study was to describe and compare temporal parameters of the four turning techniques most used by top swimmers in Freestyle events.

METHODS: Seventeen national level swimmers (nine male and eight female) participated in this study. Mean \pm SD age, height, and body mass were, respectively, 17.9 \pm 3.2 years, 1.73 \pm 0.09 m and 64.5 \pm 11.9 kg. Written consent was obtained from subjects on a consent form previously approved by the Ethical Committee for Research on Humans of the University of the State of Santa Catarina, Brazil.

Prior to data collection, the swimmers went to the laboratory to take lessons to learn all of the four analyzed turning techniques (considering the rolling, wall support, pushing and gliding phases, based on Pereira et al., 2006): (A) dorsal rolling, lateral touch in the wall, pushing with rotation and ventral gliding; (B) dorsal rolling, dorsal touch in the wall, pushing with rotation and ventral gliding; (C) dorsal rolling, lateral touch in the wall, pushing in a lateral position and lateral gliding; and (D) lateral rolling, lateral touch in the wall, pushing with rotation and ventral gliding.

In order to teach the different techniques to the swimmers, two practice and two theoretical lessons with 1:30 h of duration each (total of six hours) were carried out. The swimmers participated in specific exercises for all of the turning techniques in duos or trios in order to better memorize the technical actions. During the practical lessons feedback was continuously provided to the swimmers by the researchers. During the theoretical lessons, an audiovisual feedback was given to the subjects through the use of video images.

After the lessons, the data collection was scheduled for each swimmer. All the tests were carried out in a 25 x 12.5 x 2 m indoor swimming pool and the water temperature was set at 27.5°C. As soon as the swimmer arrived to the pool area, the anthropometrical measures were obtained and then a video with images of the four analyzed techniques was shown to the subject, in order to reinforce the technical characteristics of each one.

Each swimmer performed three times each of the four analyzed turning techniques, at maximum speed, that is, 12 flip turns per subject. The order of the executions was randomly determined and a two minute interval was given between each trial.

Performance was videotaped using four underwater and two surface fixed cameras (Sony® DCR-HC42E, 50 Hz). The trials started and finished from a specific and marked spot (at 12.5 m from the turning wall). The analyses comprised four intermediate phases of a flip turn: (1) *rolling*, which starts on the last frame before hand's entry in the last swimming stroke before turning and ends on the last frame before the first touch in the wall; (2) *wall contact*, which starts on the frame that corresponds to the first wall contact and ends on the last frame before the swimmer starts to extend the knees in order to project the body away from the wall; (3) *pushing*, which starts in the frame that corresponds to the first knee extension and ends on the frame that corresponds to the last wall contact; and (4) *gliding*, which starts on the first frame after the swimmer completely leaves the wall and ends on the frame that corresponds to the wider stage of the first leg kick out of the wall.

The analyzed variables were the time duration, in seconds, of each turn phase: rolling time (RT), wall contact time (WCT), pushing time (PT) and gliding time (GD). Additionally, the total turn time (TT), which corresponds to the sum of RT, WCT, PT and GD, was calculated for each subject.

In order to obtain these variables, the video images were digitized using the APAS system (Ariel Dynamics, USA). The frames of interest for each phase were selected and then the time was calculated based on the sampling frequency of the video cameras. It was considered an error of 0.02 s (which corresponds to 1 video field) when determining the beginning and the end of each analyzed phase.

During the video analysis some executions were excluded because the swimmer was not able to perform one or more phases of the turn according to the technique he/she was asked to use. Thus, 154 turns were selected for the statistical analysis.

SPSS version 15.0 software (SPSS Inc., Chicago, IL, USA) was used to analyze the data. Mean and standard deviation were calculated for each variable and repeated measures ANOVA was used for the comparison between the four techniques. An alpha level of 0.05 was used for all statistical tests.

RESULTS: Table 1 shows the mean and standard deviation of the rolling time, wall contact time, pushing time, gliding time and total turn time for each analyzed technique and also the p-values resulted from the statistical comparison between the techniques.

When comparing the analyzed turning techniques, no statistical differences were found for any variable.

DISCUSSION: In the European Junior Swimming Championships in Prague, 2009, the winner of men's 100 m Freestyle Final event finished the race in 48.48 s. The race analysis (Haljand, 2009) showed he performed the turn faster than the other finalists, earning something like 0.4 s during this phase, in comparison to the swimmer who ended at the second place, only 0.32 s behind him. Because of this kind of situation, although there were no statistical significant differences between the techniques investigated in this study, some

Table 1
Means (SD) of the analyzed variables and p-values resulted from the comparison between the four turning techniques

TURNING PHASE	TURNING TECHNIQUE				P
	A	B	C	D	
 Rolling Time (s)	1.291 (0.177)	1.285 (0.247)	1.347 (0.187)	1.331 (0.254)	0.728
 Wall Contact Time (s)	0.144 (0.033)	0.152 (0.051)	0.136 (0.044)	0.139 (0.054)	0.712
 Pushing Time (s)	0.253 (0.053)	0.260 (0.080)	0.259 (0.072)	0.258 (0.081)	0.988
 Gliding Time (s)	0.682 (0.198)	0.728 (0.213)	0.651 (0.190)	0.672 (0.193)	0.755
Total Time (s)	2.372 (0.319)	2.427 (0.331)	2.394 (0.339)	2.401 (0.398)	0.957

issues can be pointed out, considering that at a high competition level, very small differences of time - that might not be identified by statistical tests – could be decisive.

Regarding the rolling time, Lyttle and Mason (1997) presented average values of 0.72 s, while Haljand (1998) suggested that this time should range from 0.70 s to 0.83 s. Although these values are considerably smaller than those found in this study, it is important to mention that the instant used to determine the beginning of rolling is different between studies. Haljand (1998), for example, considers the moment the head starts rolling as the initial point, i.e. after the end of the last swimming stroke before turning.

Concerning the wall support phase, it seems the technique B tends to higher values. This is the only technique among all of the analyzed ones, whose support is performed in a dorsal position. Counsilman (1984) suggested that the lateral positioning of the body during the wall contact favors an effective push-off. However, Teel (1998) suggested that the turn could be faster when using the dorsal support. Araujo et al. (2003), comparing the dorsal and lateral positions, reported better results for the lateral technique. It is assumed that when the swimmer touches the wall with his feet pointing to the water's surface – as in technique B – even though he/she is able to roll faster, more time should be spent to adjust the body in a suitable position to perform the subsequent impulse.

The results of the pushing phase times were very similar between the four techniques. However, we believe that the pushing with rotation – as observed in techniques A, B and D, which were used, according to Pereira et al. (2006), in 84.9% of the flip turns performed by the world's top swimmers – is more efficient when considering the next turn phase – the glide. This belief is mainly supported by the reason that the swimmer's body would be already ventrally positioned during the gliding phase. According to Costill et al. (1994), during this phase a ventral position should be maintained in a hydrodynamic condition until the swimming speed is reached.

According to Lyttle et al. (2000), it seems that there is no difference between the lateral and ventral gliding techniques. However, if the swimmer rotates the body during the pushing phase, it is important that this rotation is completed before starting to glide, in order to avoid higher drag forces during the gliding phase. Although the technique B trended to longer gliding times, we must remember that the distance traveled by the swimmer during this phase, and then the speed of displacement, should be considered in order to better support the comparison between the techniques.

When considering the combination of all phases, it seems that the technique A tends to provide a smaller total time, while the worst results were found for the technique B. However,

it is possible that the intra-technique variance could have masked possible statistical differences between the analyzed techniques.

CONCLUSION: This study is the first to investigate temporal parameters in different techniques in the Freestyle flip turn. The four analyzed turning techniques did not distinguished in terms of temporal parameters considering the total turn time, and also the partial times observed during the rolling, wall contact, pushing and glide phases. Apparently, the choice of any of the techniques can be made accordingly to the swimmer's subjective preference or based on the objective performance differences casuistically sustained. Authors believe that further analyses considering other kinematic variables associated to other performance indicators could provide a better support for the determination of the most efficient turning technique.

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