EVALUATING THE TECHNICAL RACE COMPONENTS DURING THE TRAINING SEASON

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At present the analysis of race components during the international swimming competition is a usual activity but it seems insufficient to obtain this type of data only once or twice each year. Our purpose is to show different methods of monitoring these variables: a global method (TSAS), progressive tests and isolated tests. Sample results are shown to see the modifications of the race components after training periods. Isolated specific training drills are necessary to improve these race components, thus the negative improvement observed after the application of traditional no specific training.

KEY WORDS: Swimming technique, swimming race components

INTRODUCTION: During the last ten years most of the more important international competitions have been analysed by different research groups. These analyses include all the race components (r.c.) as defined by Hay, Guimaraes, & Grimston (1983): start time, swimming time and turning time. More recent studies include the final time as well (Arellano, Brown, Cappaert, & Nelson,1994; Haljand & Absaliamov, 1989). Previous studies measured only the swimming components: mean speed (MS), stroke frequency (SF) and stroke length (SL) (Craig, Boomer, & Gibbons ,1979; Craig, Skehan, Pawelczky, & Boomer ,1985; Grimston & Gay,1986). With the initial methodology, applied in older studies, the results were published some months after the competition. This technology is now substituted by more advanced systems where the results are produced a couple of hours after the finish of the competition session and they include data of all the race components.

Table 1 Collected Published Materials with the Results of Cinematic Analysis of Competitive Activity Obtained During International Swimming Competitions

Year	Authors	Competition
1980	Absaliamov et al.	Olympic Games. Moscow. USSR. Some data published at 1988.
1989	Haljand et al.	European Championships. Bonn. German
1992	Arellano, Brown, Cappaert & Nelson	Olympic Games. Barcelona. Spain.
1993	Arellano, Sánchez & Aymerich	World Short Course Championships. Palma de Mallorca. Spain.
1994	Haljand & Saagpakk	World Championships. Rome. Italy
1994	Smith et al.	Commonwealth Games. Victoria. Canada
1995	Smith et al.	Pan Pacific. Atlanta. USA
1995	Haljand et al.	European Championships. Vienna. Austria.
1996	Smith, Cappaert, Curry, Van Heest, Kranenburg, Kwon, Lefort, Luy, Maki, Mason, Norris	Olympic Games. Atlanta. USA
1997	Haljand et al.	European Championships. Sevilla. Spain.
1998	Mason, Cossor, Daley, Page, Steinebrom, Cornelius, Lyttle & Sanders	World Championships. Perth. Australia
1999	Haljand et al.	European Championships. Istanbul. Torquay
1999	Haljand et al.	Junior European Championships. Moscow. Russia.
1999	Mason et al.	Pan Pacific. Perth. Australia

This new technology was developed in the ex-USSR to analyse the 1980 Moscow Olympic Games and refined by Haljand & Absaliamov (1989). Many swimming research and evaluating groups are working in the world and they applied this technology or developed their own technology to evaluate international competitions (see Table 1) or their national competitions. Some groups in Spain, France or Germany have been developing these analyses in their National Senior Competitions since 1989.
The data obtained give a unique opportunity to the swimmer and coach to know which race component results are good or not good in comparison to the rest of the competitors. This information is applied to modify the future training plans of the swimmer to improve the poorer race components. The problem is that assessment is made only once or twice every year during the important competitions. This is insufficient to monitor the correct application of a training plan. Some questions can be asked now:

- How does one use the results of race component analysis during training?
- How are the isolated race components being trained?
- How does one know whether there is improvement in each race component?
- What is the limit of the improvement?

Our purpose is to describe several systems used to assess the race components during the training season.

OVERALL EVALUATION OF THE RACE COMPONENTS: The objective is to measure the race components during the season by means of global tests. From the eighties, our evaluation group has been assessing the race components with different procedures. During 1995 we had the opportunity to design a new 50m swimming pool and include the equipment needed to measure all the race components very accurately. The swimming pool was included in the facilities of the Altitude Training Centre (CAR) of Sierra Nevada (Granada, Spain). One year after the completion of the swimming pool we finished the development of TSAS (Temporal Swimming Analysis System). Until now more than four thousand swimmers have been evaluated using this procedure, from age group swimmers to international swimming champions. Some research papers were published in the proceedings of International Symposia using the TSAS system: Arellano, García, Gavilán, & Pardillo (1996); Arellano, Gavilán, García, & Pardillo (1997); Arellano, Pardillo, & García (1999).
Instrumental. The TSAS was composed of five video cameras connected to a SVHS video recorder (50 Hz) through a video-timer and a video selector (see figure 1). The image from the first two video cameras was mixed to see the over- and under-water phases of the start in the same frame (until 10m). A third camera was used to measure the 15m time. A fourth camera was put in the middle of the swimming pool (25m) to record at least one complete underwater stroke cycle and the 25m time (with the head). The fifth camera was placed at the end of the swimming pool for video recording the turning phase. All the cameras were recording at a distance of 15m from the sagittal plane of the swimmer. The first was placed over the water. The other cameras were placed 1 m below the water-surface viewing through three different underwater windows. One simple reference system was put in the swimmer's mid-sagittal plane and recorded before the swimmer's group performances. Thanks to this reference, it was possible to draw vertical lines on the computer screen (video-overlay) to measure the frame where the swimmer's head crossed these reference lines. The evaluation was executed after a swimming start following the FINA rules. The starting signal was synchronised with the video-timer (time code) and the swimming pool electronic timing system. The 50m time was measured with this latter device when the swimmer touched the timing wall. After video recording, the timing data were collected directly from the tape, reading with a PC connected to the video player the time code recorded. A specific database was developed for collecting the data and to produce the printout with the analysis for information for coaches and swimmers.
Variables measured. The start time was measured for 5m (T5), 10m (T10) and 15m (T15) when the head of the swimmer crossed these reference lines. The duration of the block time (BT), flight time (FT) and entry time (ET) were measured as parts of the start time. Mean speed variation was measured between 0 to 5m, 5 to 10m and 10 to 15m. The 25m time

(T25) and 50m time (T50) were collected as well plus the 42.5 m time (T42.5), 45m time (T45), 55m time (T55) and 57.5m time (T57.5).

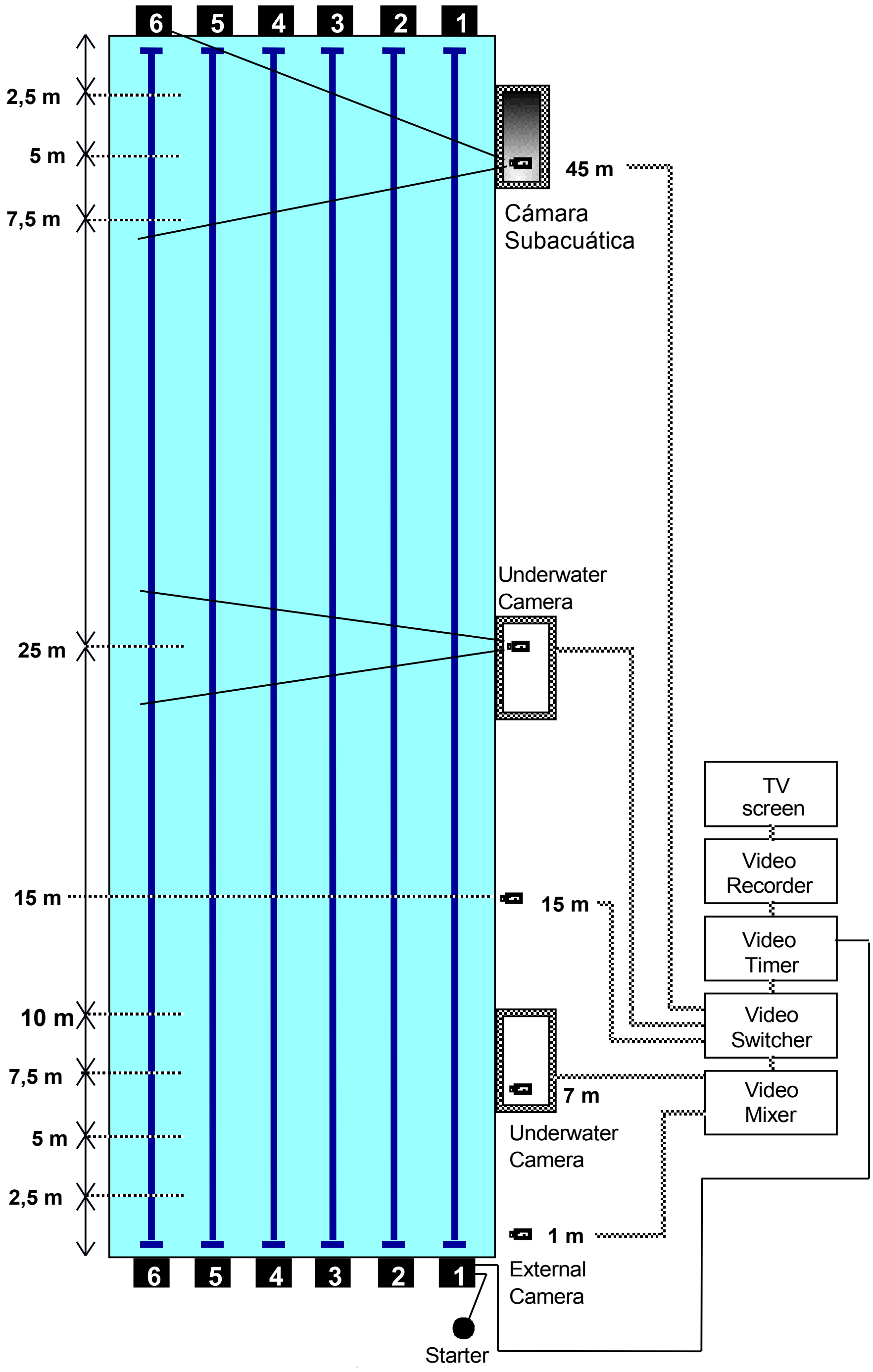
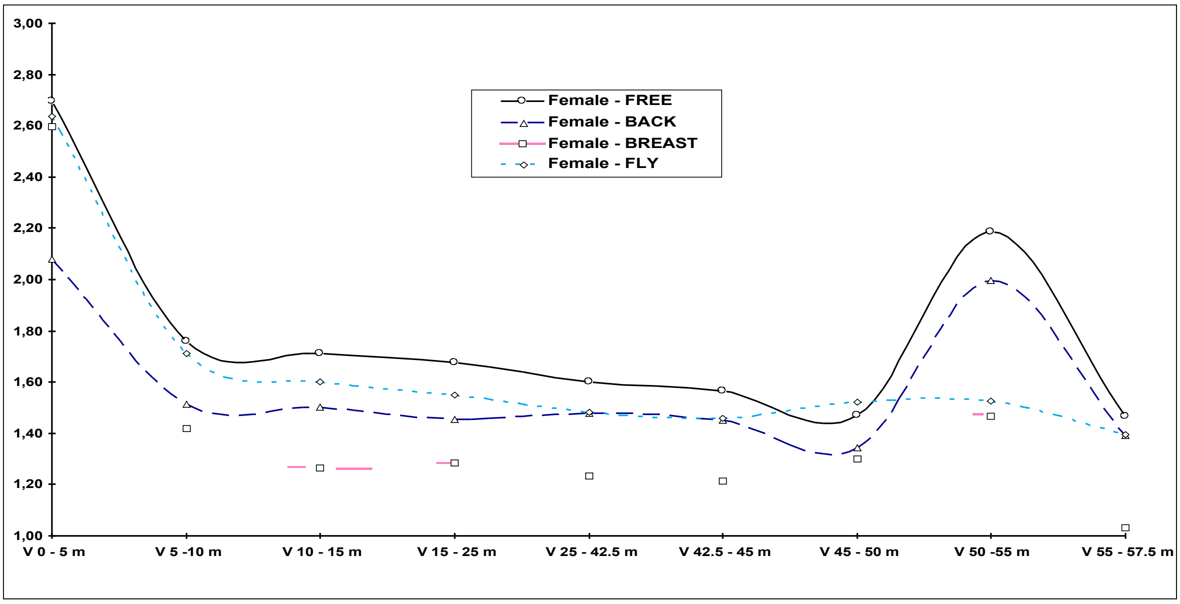


Figure 1 - Testing set-up to apply the Temporal Swimming Analysis System (TSAS).

In freestyle and backstroke the turn-in time (TI) was measured from when the head of the swimmer crossed the 7.5m reference line before the turn until the feet touched the wall and the turn-out time (TO) was measured from when the feet touched the wall until the head of the swimmer crossed the 7.5m reference line after the turn. In butterfly and breaststroke TI was measured when the head of the swimmer crossed the 7.5m reference line before the turn until the hands touched the wall and TO was measured from when the hands touched the wall until the head of the swimmer crossed the 7.5m reference line after the turn. In the first case, the body turn is included in TI and in the second case the body turn is included in TO. The differences between TI and TO were calculated (Dif). Mean speed variations were measured as well between 42.5 to 45m, 45 to 50m, 50 to 55m and 55 to 57.5m. The mean swimming speed (MS) between 15m and 42.5, between 15 and 25 (MS1), and between 25 and 42.5 (MS2) were collected (Table 2). The mean stroke rate (SR) was obtained dividing one stroke cycle by the time measured during one stroke from the video-recorded frames (50 Hz). The stroke length (SL) was calculated by dividing the MS by SR. The stroke index (SI) was calculated as the product of MS and SL.



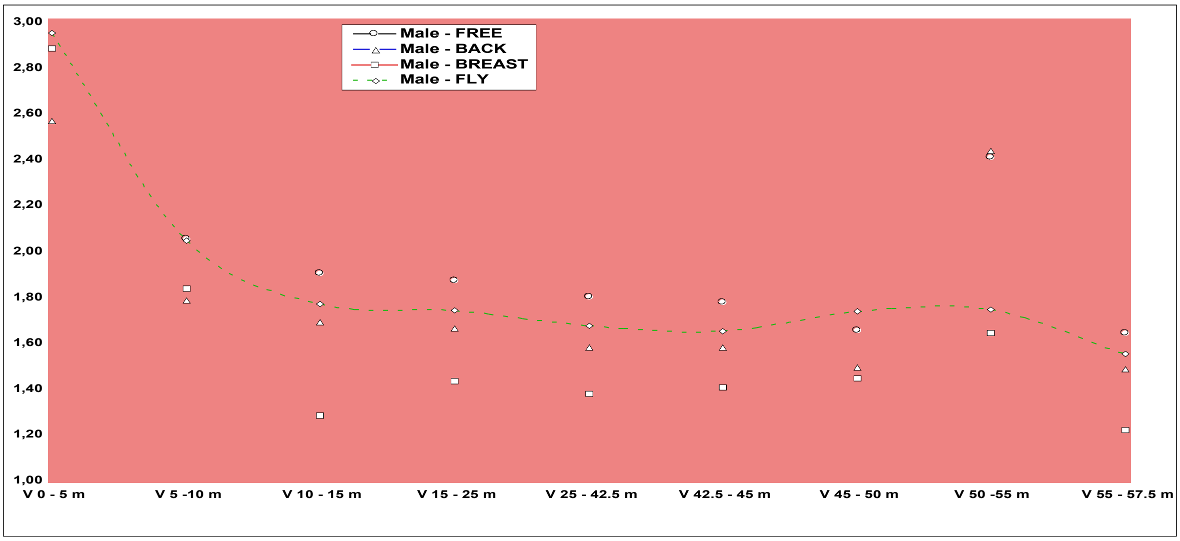


Figure 2 - Mean speed variations obtained during the performance of the test 50-m and turn. The different lines show the data of each stroke of the female and male group. Each group was composed of the 20 best trials filed by stroke and sex from the swimmers evaluated in CAR of Sierra Nevada by Arellano et al. (1999).

Table 2 **TSAS results of a world ranked female breaststroker during two altitude training camps before participating in Atlanta Olympic Games**

date	BT	FT	ET	T5	T10	T15	T25	T42.5	T45	T50	T55	T57.5	MS	SR	SL	SI
3/1/96	0.87	0.40	0.32	1.85	5.35	9.03	16.44	30.5	32.5	36.23	39.56	41.84	1.28	51	1.48	1.90
22/6/96	1.07	0.38	0.32	2.11	5.73	9.58	17.35	31.73	33.75	37.98	41.21	43.5	1.24	46	1.58	1.97

Table 2 shows the results of two tests performed almost 6 months apart. Nearly a month before the Olympic Games the swimmer presented a proportional temporal increase in all the race components. This situation is not expected so close to the Olympics. A larger block time increased the total time of the start and the decrease of the SF produced a reduction of the swimming MS. A detailed review of the stroke technique showed small modifications in the stroke movements and co-ordination. The performance in the Olympic Games was worste than anticipated. A modified version of the TSAS was developed to make analyses in 25m swimming pools making it easier to perform the protocol with very young age group swimmers.

PROGRESSIVE TESTS: The objective is to analyse the swimming technical components (MS, SF & SF) by means of a set of swimming incremental speed repetitions. The basic model proposed is a set of 6 or 8 repetitions of 50m progressive trials utilising a 50m swimming pool. During the first trials of this test a similar recovery time was used for all repetitions, for example leaving each minute. We introduced some modifications to make sure to obtain a sufficient speed at the last repetitions: four times 50s increasing the speed leaving each minute, two 50s leaving each two minutes and two more leaving each three minutes.

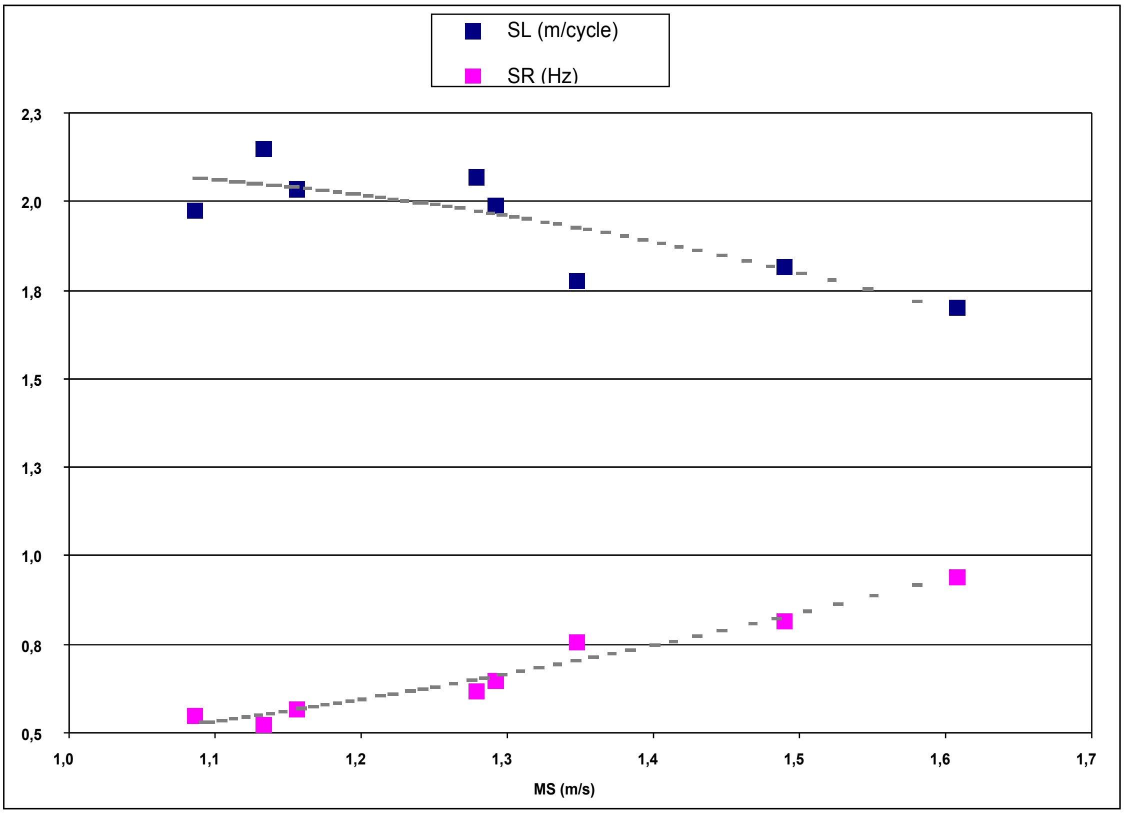


Figure 3 - Sample data of a progressive test done by an age group freestyle swimmer.

Instrumental. To be able to evaluate a large group of swimmers simultaneously, three cameras were placed along the swimming pool: two at 10m from both ends and one in the centre. References were placed at 10m prior to the subjects' trials and recorded. The swimmers were asked to start relatively slowly (almost aerobic threshold) and finishing as close as possible to the competitive pace.
The graphs obtained from the data (see figure 3) let us relate SL and SF with MS. We can measure the technical improvement of the swimmer if at similar speeds the SL is increased and SF decreased or if higher speeds are obtained with similar SF and longer SL. These effects are produced with a relatively long period of training (at least one meso-cycle).
This test has been adapted to a 25m swimming pool and it can be arranged without equipment. The swimmer performs eight times 25m progressive in a similar way as described above. The coach starts measuring the time at the instant the head crossed the 5m line, measuring the SR in the middle of the swimming pool and stopping the timer when the swimmer touches the wall. Mean speeds for 20m are calculated. This test modification is very useful with age group and master swimmers.

ISOLATED TESTS: These testing procedures are targeted to measure the start and turn evolution during the training season. The methodology and parameters measured are the same as TSAS.
Starts. The procedure is to measure three start trials until the head crosses the 15m mark (full rest is permitted after each trial). The mean of the three trials is kept so that the improvement during the training season can be measured. An aquatic force plate has been included in our starting and turning protocols. This will give kinetic results and make the system more accurate.

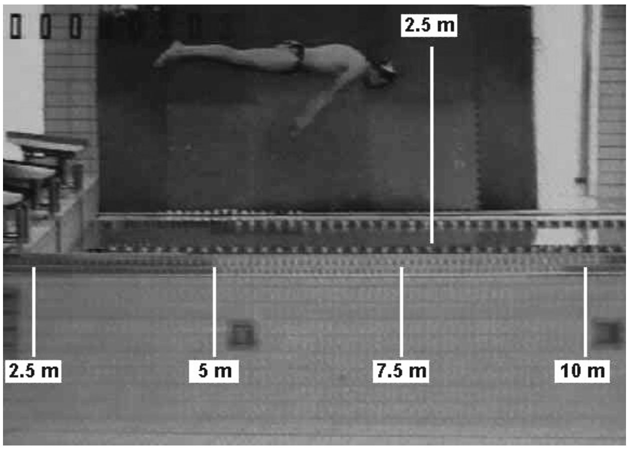


Figure 4 - Images from the camera 1 and 2 mixed in the same frame to measure the starting times.

The subjects (breaststroke swimmers) of Table 3 obtained similar times in the block, flight and entry phases. S2 and S3 are swimmers of similar medium level. S1 is a Spanish elite swimmer. The differences in T5 and T7,5 between S1 and S2-S3 are due to higher values of Vz and Fz (more than 20% of related body weight force) and a better horizontal body position. The increase of the time difference at T10 is produced by a better propulsion obtained during the first underwater arm pull. The 15m time difference includes the first two or three strokes.

Table 3 Shows the Differences between Three Swimmers in Their Starting Times, Cinematic and Kinetic Data. You Can See Where a Swimmer is Gaining on the Others

	THLB	TFLB	T2,5m	THE	TFE	T5m	T7,5m	T10m	T15m
S1	0.48	0.86	1.02	1.22	1.54	1.60	2.62	4.04	7.82
S2	0.69	0.91	1.13	1.37	1.67	1.83	3.07	4.91	8.88
S3	0.57	0.85	1.06	1.27	1.67	1.81	3.01	4.80	8.66

THLB: Time hands leave the block. TFLB: Time feet leave the block. THE: Time hand entry. TFE: Time feet entry.

	Vz (m/s)	Vy (m/s)	Fz (N)	Fy (N)	φ (degrees)	%Fz/W
S1	4,36	-0,20	1017	431	-2,67º	30%
S2	3,62	0,53	728	700	8,30º	6%
S3	3,60	0,01	647	647	0º	9%

V: velocity, z: horizontal, y: vertical, F: force, W: body weight. φ: take-off angle.

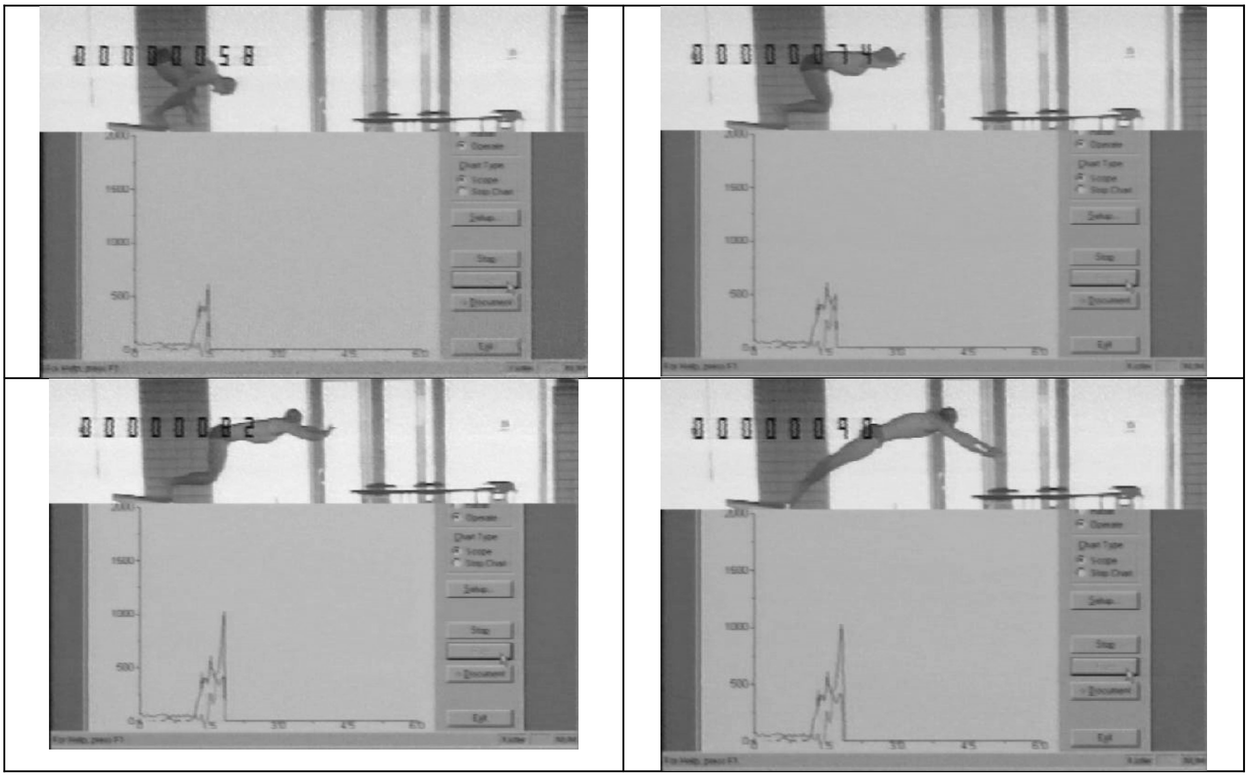


Figure 5 - A sample of integration of video images with the kinetic data.

Turns. The procedure is to measure 7.5m in and 7.5m out of the turn and their phases utilising the TSAS. The swimmer starts swimming 12 m before the wall to ensure a speed as high as possible before the 7.5m mark. Two or three trials are recorded each evaluating session.

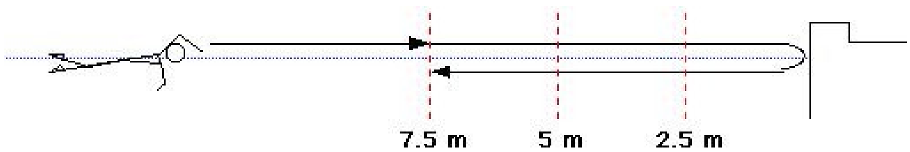


Figure 6 - Turning phases measured by timing system.

Table 4 Shows the Differences Between Two Swimmers in Their Turning Times and Velocity. You Can See Where a Swimmer is Gaining on the Other

	Total Turn Time (15 m) 7.5 m in + 7.5 m out (s)	Total Turn Time (10 m) 5 m in + 5 m out (s)	Turn in time (s) 7. 5 m	Turn out time (s) 7.5 m
S1	7.68	4.62	4.36	3.32
S2	8.48	5.20	4.64	3.84

	Time in (s) 7.5 – 5 m	Time in (s) 5 – 0 m	Time out(s) 0 – 5 m	Time out(s) 5 – 7.5 m	V (m/s) 7.5 – 5 m	V (m/s) 5 – 0 m	V (m/s) 0 – 5 m	V (m/s) 5 – 7.5 m
S1	1.46	2.90	1.72	1.60	1.72	1.72	2.91	1.56
S2	1.56	3.08	2.12	1.72	1.60	1.62	2.36	1.45

Table 4 compares two Spanish swimmers. S1 is a country sprint champion and S2 is a top 200m swimmer. The differences in total turning time 15m and 10m are 0.8s and 0.58s respectively. The longer time difference was found in the turn out time (0 – 5 m). S1 performed undulatory underwater swimming very efficiently in this phase. S2 glided and started swimming freestyle before crossing the 5m mark. Both swimmers decreased the mean swimming speed between 5 and 7.5m in the turn-out phase related to the turn-in phase. These results are produced because the transition from turn-out to swimming was done in a not efficient way.

CONCLUSIONS: A periodic plan of testing the race components using some of the methods proposed seems the most adequate system to monitor the effects of the training plan on swimming technique.

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