EVOLUTION OF ANTHROPOMETRIC AND KINEMATIC PARAMETERS IN BREASTSTROKE, BACKSTROKE AND BUTTERFLY YOUNG SWIMMERS

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ABSTRACT

The aim of this work has been to determine the anthropometrical and kinematic variations in competition for the events of 100 and 200 meters of the styles breaststroke (BR), backstroke (BA) and butterfly (FLY) of young swimmers.

It is a longitudinal study with 69 male and 72 female swimmers of national level. The analysed anthropometric variables have been: weigh, height, arm span, length of the hand and length of the feet. The analysed kinematic variables have been: stroke length, stroke frequency and stroke index. The data was obtained during the Winter National Age-Group (1994) and Junior (1996) Championships organized by the Royal Spanish Swimming Federation. Only those participanting in both championships were analysed in this study. Among the anthropometrical variables, the W and LF values are those that, in percentage terms, experience a bigger increase. On the evolution of the kinematic parameters, an increase of the values is observed in S, LC and IS whereas the variable FC tends to reduce its value as they grow up. Finally, the swimmer seems to have a better performance based on the increase of his anthropometrical parameters and on the increase of the LC and IS

KEYWORDS: swimming, swimming speed, stroke frequency, stroke length and stroke index

INTRODUCTION: Swimming kinematics parameters like stroke length SL, stroke frequency SF and stroke index SI have been widely applied to measure swimming skill in training and competitive situations (Craig and Pendergast, 1979; Keskinen, Tilli and Komi, 1989). These studies had several aims: to evaluate the evolution of the swimming technique during the season, to compare different populations and to detect the strong and weak technical points of the group. Related to anthropometrical parameters it is important to emphasize Boulgakova's works (1990) about their evolution and their relationship with the performance, and whose aim was to analyse the evolution of the swimming kinematics parameters related to anthropometrical data in the age-group.

METHOD

The study data was obtained during the Winter National Age-Group (1994) and Junior (1996) Championships organized by the Royal Spanish Swimming Federation. The swimming pool was 25 m long.

The analysed age groups have been:

	Age-group	Junior
male	14-15	16-17
female	12-13	14-15

The sample analysed was as follows:

	200FLY	100FLY	200BA	100BA	200BR	100BR	Total
m	1	14	14	17	7	16	69
f	6	14	6	18	8	20	72

m - male *f* – female FLY – butterfly BA – backstroke BR - breaststroke

The variables studies are shown in the table 1. Trained observers recorded the splits and the three-cycle time, every event lap. Mean swimming velocity (SV) was calculated every lap. The anthropometrical variables were measured after finishing each race. Only those participating in both championships were analysed in this study.
SPSS statistical software for Windows 95 (v. 6.1.3.) was utilised for the analysis of the swimmers' data.

Table 1. Kinematics and anthropometrical variables measured and analysed.

Kinematics	Anthropometrical
SF (cycles/m) SL (m/cycle) average swimming velocity SV (m/s) SI (SV x SL)	Arm span (AS) (cm) Length of the hand (LH) (cm) Length of the feet (LF) (cm) Height (H) (cm) Weight (W) (kg)

Means, standard deviations and percentages of difference were calculated for all the variables shown in the Table 1. T- tests for related samples were performed to compare the averages in both championships.

RESULTS:
All the anthropometrical variables showed a positive increment after two years in the male and female groups (Table 1 and 2). For the male swimmers W increased by 17.3%, H increased 5.6%, LF increased 13.1%, LH increased 7.8% and the AS increased 6%. For the female group W increased by 21.1%, H increased 5.6%, LF increased 12.4%, LH increased 4.9% and the AS increased 5.3%. The values of W and LF percentage of improvement showed a higher increment.
T- test averages comparisons showed in most cases significant differences (p > 0,05 and p> 0,01) except in:
- The LH in the female 200BA events.
- The W in the female 200BA.

Table 1. Average values of the anthropometrical variables of the AS, LH, LF, H and W male swimmers

	100m (n = 12)	200m (n = 1)	100e (n = 17)	200e (n = 12)	100b (n = 15)	200b (n = 7)
AS_{94}	**172,25 ± 4,08****	170,00	**175,00 ± 7,23****	**176,25 ± 6,87****	**175,63 ± 8,49****	**177,00 ± 4,20****
AS_{96}	**182,95 ± 6,21****	191,00	**183,73 ± 5,84****	**186,12 ± 5,97****	**185,70 ± 8,33****	**185,64 ± 7,39****
LH_{94}	**18,35 ± ,72****	17,00	**18,76 ± 1,06****	**19,17 ± ,95****	**18,64 ± ,75****	**18,98 ± ,78****
LH_{96}	**20,12 ± 1,06****	21,50	**19,70 ± ,79****	**19,79 ± ,91****	**20,03 ± ,81****	**20,14 ± 1,18****
LF_{94}	**23,20 ± ,78****	21,20	**24,11 ± 1,34****	**24,85 ± 1,08****	**24,66 ± 1,30****	**25,31 ± 1,44****
LF_{96}	**27,00 ± ,97****	28	**26,88 ± 1,09****	**27,04 ± 1,07****	**27,66 ± 1,17****	**27,78 ± 1,46****
H_{94}	**165,16 ± 4,35****	155,00	**168,77 ± 6,59****	**170,57 ± 5,22****	**170,72 ± 7,65****	**172,71 ± 4,22****
H_{96}	**174,43 ± 4,82****	179,00	**176,50 ± 5,30****	**178,45 ± 5,58****	**178,74 ± 6,79****	**179,08 ± 6,35****
W_{94}	**61,95 ± 8,81****	53,00	**59,38 ± 7,08****	**61,33 ± 8,23****	**59,53 ± 6,20****	**62,25 ± 4,05****
W_{96}	**68,16 ± 6,03****	67,50	**69,84 ± 7,82****	**70,31 ± 9,36****	**67,85 ± 7,16****	**70, 72 ± 5,34****

* p>0,05 ** p>0,01

Table 2. Average values of the anthropometrical variables of the AS, LH, LF, H and W female swimmers

	100m (n = 13)	200m (n = 6)	100e (n = 17)	200e (n = 6)	100b (n = 20)	200b (n = 8)
AS_{94}	**157,63 ± 4,89****	**159,75 ± 5,58****	**161,29 ± 6,12****	**161,33 ± 5,35****	**157,47 ± 6,06****	**161,25 ± 3,78****
AS_{96}	**165,23 ± 8,11****	**167,58 ± 4,77****	**169,50 ± 6,52****	**171,58 ± 6,16****	**168,47 ± 7,54****	**171,68 ± 5,94****
LH_{94}	**16,90 ± 1,09****	**17,30 ± ,54***	**17,26 ± ,85****	17,66 ± ,75	**16,82 ± ,73****	**17,21 ± ,77****
LH_{96}	**17,80 ± ,96****	**18,25 ± ,41***	**18,26 ± ,95****	18,41 ± 1,06	**18,20 ± ,76****	**18,12 ± ,87****
LF_{94}	**21,84 ± 1,22****	**21,36 ± ,68****	**21,93 ± ,87****	**22,28 ± ,44****	**22,03 ± 1,31****	**22,62 ± 1,27****
LF_{96}	**24,76 ± 1,81****	**25,25 ± ,68****	**24,82 ± 1,06****	**25,16 ± 1,16****	**24,92 ± ,84****	**24,75 ± 1,03****
H_{94}	**150,82 ± 6,41****	**151,11 ± 8,80****	**157,13 ± 6,11****	**157,85 ± 3,08****	**155,64 ± 6,17****	**158,72 ± 4,30****
H_{96}	**160,83 ± 6,76****	**164,20 ± 5,21****	**165,49 ± 5,61****	**167,33 ± 3,84****	**164,66 ± 5,87****	**165,66 ± 5,09****
W_{94}	**44,69 ± 6,18****	**45,58 ± 4,85****	**45,32 ± 6,34****	**46,41 ± 2,57****	**43,97 ± 6,05****	**45,43 ± 4,44****
W_{96}	**53,61 ± 5,88****	**54,66 ± 3,86****	**55,82 ± 6,66****	**55,50 ± 3,83****	**54,17 ± 7,59****	**56,12 ± 5,91****

* p>0,05 ** p>0,01

In general terms the SV, SL and SI averages increased significantly between championships while the SF reduced its average values in the male and female groups.

Table 3. Average values of the kinematics variables of the FLY, BA and BR male swimmers

	100FLY (n = 14)	200FLY (n = 1)	100BA (n = 17)	200BA (n = 14)	100BR (n = 16)	200BR (n = 7)
SF_{94}	55,38 ± 3,95	54,43	44,04 ± 4,17	37,07 ± 3,38	50,87 ± 5,72	**46,56 ± 3,56***
SF_{96}	54,45 ± 1,68	52,49	44,09 ± 4,39	36,59 ± 2,94	52,95 ± 3,85	**42,84 ± 3,93***
SI_{94}	**2,65 ± ,16****	2,38	**3,19 ± ,38****	**3,55 ± ,45****	**2,24 ± ,25***	**2,17 ± ,21****
SI_{96}	**2,96 ± ,14****	2,80	**3,60 ± ,43****	**3,88 ± ,40****	**2,37 ± ,26***	**2,69 ± ,22****
SL_{94}	**1,69 ± ,10****	1,62	**2,09 ± ,20****	**2,40 ± ,25****	1,63 ± ,16	**1,67 ± ,13****
SL_{96}	**1,80 ± ,06****	1,79	**2,22 ± ,23****	**2,53 ± ,21****	1,64 ± ,14	**1,95 ± ,15****
SV_{94}	**1,56 ± ,04****	1,47	**1,52 ± ,07****	**1,47 ± ,05****	**1,37 ± ,05****	**1,29 ± ,05****
SV_{96}	**1,64 ± ,03****	1,56	**1,61 ± ,04****	**1,53 ± ,04****	**1,44 ± ,05****	**1,38 ± ,04****

* p>0,05 ** p>0,01

Table 4. Average values of the kinematics variables of the FLY, BA and BR female swimmers

	100FLY (n = 14)	200FLY (n = 6)	100BA (n = 18)	200BA (n = 6)	100BR (n = 20)	200BR (n = 8)
SF_{94}	**51,44 ± 5,70***	48,11 ± 5,25	43,16 ± 3,64	39,05 ± 2,65	49,66 ± 4,84	43,23 ± 2,75
SF_{96}	**54,86 ± 2,50***	49,37 ± 4,77	41,80 ± 3,94	36,58 ± 3,24	51,40 ± 4,98	43,17 ± 3,58
SI_{94}	**2,08 ± ,29****	1,99 ± ,32	**2,52 ± ,27****	**2,60 ± ,30****	**1,75 ± ,18****	1,86 ± ,07
SI_{96}	**2,25 ± ,15****	2,15 ± ,22	**2,97 ± ,38****	**3,17 ± ,30****	**1,91 ± ,22****	2,02 ± ,15
SL_{94}	1,56 ± ,19	1,58 ± ,20	**1,87 ±,17****	**2,00 ± ,17****	1,46 ± ,13	1,60 ± ,06
SL_{96}	1,57 ± ,08	1,62 ± ,16	**2,07 ± ,22****	**2,28 ± ,19****	1,50 ± ,15	1,68 ± ,13
SV_{94}	**1,32 ± ,04****	**1,25 ± ,04****	**1,34 ± ,05****	**1,29 ± ,05****	**1,20 ± ,04****	**1,15 ± ,04****
SV_{96}	**1,46 ± ,04****	**1,32 ± ,01****	**1,43 ± ,04****	**1,38 ± ,05****	**1,27 ± ,03****	**1,20 ± ,01****

* p>0,05 ** p>0,01

DISCUSSION:

About the anthropometrical variables, the observed increase between both championships corresponds with the normal growth of these ages, agreeing with Leger and Lambers (1983) data, that indicated that swimming is a sport in which initiation and early training take place, when the body is below its maximum growth. In this respect, Tcherkassov and Vorontsov (mentioned by Bougalkova, 1990) obtain high H and W correlations among 11 to 16 and 16 to 19 years old swimmers.

It is to emphasized that the W and the LF were the variables that showed a higher percentage of development. This information similar to the results obtained in the transversal study between the age-group and junior populations (Tella, 1998), where similar differences between these variables were found. The reason that explain mentioned difference in W can be related to the increase of muscular mass that was consolidated with the pubertal changes plus the normal increase of training loads during this development period (Navarro, Arellano, Carnero, and Gosálvez, 1990).

When comparing these values with the ones obtained by Carter and Ackland (1994) at the Perth World Championship (Australia), we find out that the average values of the anthropometrical variables are very much lower than the ones of the world class swimmers. This difference is bigger than the hoped growth of the analysed swimmers. This difference is superior to the growth that would be expected from these swimmers when they finish their growth. What puts in evidence that the anthropometrical profiles of the Spanish swimming in the groups of age can not be suitable to compete successfully when they reach the world elite, since according to the last studies they overcome in relation to these anthropometrical variables.

As for the cinematic variables, the frequency of cycle does not experience statistically significant variations ($p > 0.05$), except the reduction observed in the male 200BR and the increase in the female 100FLY. These results do not agree with the obtained ones for Craig, Boomer and Skehan's (1981) that indicate that when there are no variations in the arm span of the swimmers the improvements of the speed are caused by the increase of the frequency of cycle. Neither correspond with the information obtained by Reischle (1993), Lavoie and Montpetit (1986), Chatard (1986), and Pelayo, Sidney, Weissland, Carpentier and Kherif (1995) where to an increase of the arm span there would correspond a reduction of the frequency of cycle.

The increase of the AS is the consequence of the biological growth of the swimmers, because it is a question of a longitudinal study. However, some shorter term studies like Craig, Boomer and Skehan's (1981) that do not report AS variations, the SV increase is a consequence of the SF augmentation.

On the other hand, comparing SV among age-group swimmers and junior swimmers in the same season (transversal study), no statistical significant differences were found ($p>0.05$) (Tella, 1998). However, comparing the evolution from age-group to junior (longitudinal study), some SV improvements were found in all the events ($p<0.01$).

It has been found a significant AS increase in both sexes. Likewise, SL increased in all the male events, except for the 100BR, whereas SL increased only in 100BA and 200BA female events. These results suggest that, besides AS, other not analysed variables in the current study like force levels (Malina and Bouchard, 1991) and active resistance levels (Huijing, Toussaint, Mackay, Vervoon, Clarys, Hollander and Groot, 1988) influence SL in a different way depending on the sex.

Likewise, these results are partially coincident with the ones Saito (1982) presented, who reported correlations between the SV and LC increase, as age increases.

On these bases, Saito (1982) already clarified that the increase of speed related to an increase in age is tied principally to the increase of the SL.

The increase produced in the SI emphasises the high value that takes this index as an indicator of the improvement in the performance

To conclude, the evolution observed in the kinematics variables and anthropometrical variables in young swimmers shows the improvement in the speed depends SL resulting in part from the increase in anthropometrical variables.

Once the evolution of the studied anthropometrical variables has finished, the relationship between SF and the improvement of SV will be more relevant.

Consistently, it is recommended to control the anthropometrical parameters evolution valued at the present study, besides the kinetic and energetic parameters (indicated by other authors), in the analysis of cinematic behaviour in young swimmers.

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