EVOLUTION OF ANTHROPOMETRICAL AND KINEMATIC PARAMETERS IN YOUNG SWIMMERS: A LONGITUDINAL STUDY

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Swimming kinematics parameters have been widely applied to measure the swimming skill in training and competitive situations. The descriptive study aim was to analyse the evolution of the swimming kinematics parameters related to anthropometrical data in the age-group. 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. The obtained results allow to conclude that the evolution observed in the kinematics variables and antropometrical variables in young swimmers shows the improvement in the speed depends SL resulting in part from the increase in anthropometrical variables.

KEY WORDS: swimming, swimming speed, stroke frequency, stroke length, stroke index

INTRODUCTION: Swimming kinematics parameters (stroke length SL, stroke frequency SF and stroke index SI) have been widely applied to measure the 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 point out Boulgakova's works (1990) about their evolution and their relationship with the performance. The study aim was to analyse the evolution of the swimming kinematics parameters related to anthropometrical data in the age-group.

METHOD: The study data were 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 were:

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

Studied subjects were as follows:

	1500FS	800FS	400FS	200FS	100FS	200FLY	100FLY	200BA	100BA	200BR	100BR	Total
M	6	-	14	6	17	1	14	14	17	7	16	112
F	-	3	12	13	15	6	14	6	18	8	20	115

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

The variables studies are shown in 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 participanting in both championships were analysed in this study. SPSS statistical software for Windows 95 (v. 6.1.3.) was used for the analysis of the swimmers' data. Means, standard deviations and percentages of difference were calculated for all the variables shown in Table 1. T- tests for related samples were performed to compare the averages in both championships.

Table 1. Measured and analysed kinematics and anthropometrical variables.

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)

RESULTS: *Anthropometrical variables:* All the anthropometrical variables showed a positive increment after two years in the male and female groups. For the male swimmers W increased 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 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 male 100FS and 200FS events, and in the female 100FS and 200BA events.
- The AS in the female 800FS.
- The H in the female 800FS.
- The W in the male 1500FS and in the female 200BA.

Kinematics variables: 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 2. Average of the kinematics variables of FS male swimmers.

	1500FS (n = 6)	400FS (n = 14)	100FS (n = 17)	200FS (n = 6)
SF_{94}	44.13 ± 6.36	46.35 ± 5.81	52.09 ± 4.83	48.45 ± 5.42
SF_{96}	42.83 ± 6.82	45.19 ± 5.91	51.53 ± 3.97	45.92 ± 2.79
SI_{94}	**2.93 ± .39****	**2.99 ± .46****	**3.49 ± .49****	**3.39 ± .49****
SI_{96}	**3.38 ± .53****	**3.41 ± .49****	**3.91 ± .43****	**3.93 ± .37****
SL_{94}	**2.01 ± .27****	**1.98 ± .26****	**2.01 ± .22****	**2.05 ± .25****
SL_{96}	**2.20 ± .34****	**2.14 ± .28****	**2.14 ± .19****	**2.27 ± .17****
SV_{94}	**1.45 ± .03****	**1.50 ± .05****	**1.73 ± .07****	**1.64 ± .04****
SV_{96}	**1.53 ± .03****	**1.59 ± .04****	**1.82 ± .05****	**1.73 ± .03****

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

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

DISCUSSION: *Anthropometrical variables.* The observed increase between both championships corresponds to the normal growth of these ages, according to 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.

Table 4. Average values of the kinematics variables of the FS female swimmers.

	800FS (n = 3)	**400FS (n = 12)**	**100FS (n = 10)**	**200FS (n = 13)**
SF_{94}	46.04 ± 3.39	46.27 ± 3.38	51.88 ± 6.14	47.02 ± 4.11
SF_{96}	41.61 ± 4.83	44.49 ± 3.70	52.16 ± 5.01	46.27 ± 4.48
SI_{94}	2.40 ± .21	**2.37 ± .15****	**2.75 ± .33****	**2.60 ± .25****
SI_{96}	2.83 ± .40	**2.76 ± .28****	**2.98 ± .31****	**2.92 ± .31****
SL_{94}	1.77 ± .14	**1.75 ± .10****	1.79 ± .20	**1.82 ± .16***
SL_{96}	2.02 ± .25	**1.93 ± .16****	1.85 ± .17	**1.95 ± .18***
SV_{94}	1.35 ± .03	**1.35 ± .04****	**1.53 ± .04****	**1.42 ± .03****
SV_{96}	1.39 ± .03	**1.42 ± .03****	**1.61 ± .04****	**1.49 ± .03****

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

Table 5. 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

It is necessary to emphasize that the W and the LF were the variables that showed a higher percentage of development. This information is 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 explains such difference in W can be related to the increase of muscular mass that was consolidated through the pubertal changes plus the normal increase of training loads during this period of development (Navarro, Arellano, Carnero, and Gosálvez, 1990). *Kinematics variables.* In the evolution of the SF, a decrease is noted, specially in the longer distances. This can be caused by the AS increase as some studies have already pointed out (Reischle,1993, Lavoie and Montpetit ,1986, Chatard ,1986, and Pelayo, Sidney, Weissland, Carpentier and Kherif,1995). 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, in 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), except for 200FS male and female (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), except for the 800FS female. A significant AS increase in both sexes has been found. Likewise, SL increased in all the male events, except for the 100BR, whereas SL increased only in 200FS, 400FS, 100BA and 200BA female events. These results suggest that, besides AS, other non-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 presented by Saito (1982), who reported correlations between the SV and LC increases, as age increases. On these bases, Saito (1982) had already clarified that the increase of speed, related to an increase in age, is tied mainly 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.

CONCLUSION: The evolution observed in the kinematics variables and antropometrical 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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