# STROKE INDEX VALUES ACCORDING TO LEVEL, GENDER, SWIMMING STYLE AND EVENT RACE DISTANCE

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The performance of swimmers competing in all events at the First World Short Course Championships and at the XXXVII Winter Spanish Championship were videotaped and analyzed to determine stroke length (SL), stroke rate (SR), average velocity (v) and stroke index (SI); relationships were then taking into account the final time (FT), level, gender, swimming style and event distance. Results revealed significant correlation between SI and FT at both championships in all the butterfly race distances. SI may be used as performance index being significantly greater in male swimmers than female in all the events, independently of their level. The freestyle had the greatest SI followed by the backstroke, butterfly and breaststroke. The general tendency indicates that as the distance of the race increases the SI decreases.

**KEYWORDS:** Swimming, competition analysis, stroke index, kinematic parameters.

**INTRODUCTION:** The stroke index (SI) was defined by Costill, et al. (1985) as the product of average velocity (v) and stroke length (SL), and they considered it a valid indicator of swimming efficiency.
McMurray et al. (1990) used the definition given by Lavoie et al. (1985) who suggested that this index could predict the maximum aerobic power in swimming. To calculate SI, the total number of cycles carried out in a defined distance of swimming was divided by the average velocity from the final time race event; in this way the resulting units were cycles•$(m \bullet s^{-1})^{-1}$ vs. $m^2 \bullet (s \bullet cycle)^{-1}$ according to the concept laid down by Costill et al. (1985). These latter units were employed in other research papers (Keskinen et al.1989; Wille and Pelayo, 1993; Arellano et al.1997).
The purpose of the study was to develop the stroke index concept as follows: a) to evaluate the correlation between final time (FT) and SI; b) to compare the SI among swimmers of different levels; c) to examine the differences across the several race distances and swimming styles and; d) to compare the differences between sexes.

**METHODS**: The present study evaluated 313 swimmers at the First World Short Course Championship (WC), 181 men and 313 women, and 420 swimmers at the XXXVII Spanish Championship of Winter (SC), 217 men and 203 women. All the events were recorded with three 8 mm video cameras; the first set to cover the start and the first 10 m, the second the middle of the swimming pool and the third the final 10 m at the turning end. Stroke rate (SR) and SL were calculated from the video records. To estimate SR, the time required to perform three stroke cycles was measured and then used to calculate the SR, according to the method used by Sánchez (2000). The v, which was determined for the midsection of the pool, was used in conjunction with the SR data to calculate the SL in each event lap and with this last the SI, as follows:

$$v = l_i \bullet t_i^{-1} \ (m \bullet s^{-1}); \quad (1)$$

$$SL = v \bullet SR^{-1} \ (m \bullet cycle) \quad (2)$$

$$SI = SL \bullet v \ \ [m^2 \bullet (s \bullet cycle)^{-1}] \quad (3)$$

where $l_i$ = length in meters of midsections of Lap i, and $t_i$ = time in seconds to cover the midsection of Lap i. The FT was obtained from the official swimming results of both championships. For each lap an imaginary line was interpolated between the distance markers of exterior lanes. An electronic flash activated by the starter's gun was switched on, and used to synchronise the video records with the official electronic timing. The swimming times were recorded when the swimmer's head crossed the references.

Data from both preliminary and final heats were used in the analysis. For a swimmer who competed in both heats the time for the best performance was utilized.
All results were calculated with a database program, FileMaker Pro 3.0 by Clarys (1995). The results of the events were compared by a series of ANOVAs. Scheffe test were subsequently performed to evaluate the differences.

**RESULTS AND DISCUSSION:** SI correlated for both championships with FT ($p<0.01$; $r>0.75$) in all the butterfly race distances; for the rest of the swimming styles, although there was significant correlation these never reached the value $r>0.75$, except in the 50 m WC female breaststroke ($p<0.01$; $r=-0.87$). We agree with Mason (1999) who only found a high correlation in butterfly. We consider that for the same velocity a swimmer will be more efficient if SL is higher and therefore the SI will be higher.
At both championships for males and females, the freestyle was the most effective stroke, followed by backstroke, butterfly and breaststroke. The SI values in descending order are shown in figure 1. The SI value of 50 m WC freestyle is highest in all events in both championships.
The analysis indicated, without exception, at the WC, significant differences of the SI ($p<0.01$) for gender and between events, and with the exception of 50 m breaststroke at the SC due to the high SF of women (0.97 ±0.05 $cs^{-1}$). The v also showed significant differences ($p<0.001$); however the SF values were not statistically different. The SL values of WC were significantly different ($p<0.05$) for two events (200 m freestyle and 100 m butterfly). Besides these two events the SC also presented differences in the freestyle 100 m. The values of SI, v and SL in males were higher than in females in all events. This is probably due to the difference in height between men and women which influences SL.
The men showed higher 100 m SL values than women, 9% at the WC and 11% at the SC. Kennedy et al. (1990) obtained similar values (10% approximately) at the 1988 Olympic Games. Arellano et al. (1994) established some greater differences of 9% for male freestyle events at the 1992 Olympic Games. We found 10% at the WC and 12% at the SC in the freestyle events. Therefore, our data does not differ from the studies presented before. The SL of WC was significantly higher ($p<0.001$) than the SL of SC, 5% for men and 3% for women.
When t test was calculated with the event distance as a grouping factor at the WC the SI results were significantly different ($p<0.05$) in male butterfly and breaststroke, while at the SC (by means of Scheffe test) these differences were in butterfly and male breaststroke ($p<0.05$) and even between the 200 m with respect to 50 m and 100 m. At the WC, Scheffe test showed significant differences in male freestyle events between 400 m and the other distances; at the SC they were between 100 m and the rest distances. For women the SI also decrease at longer distances, and while at the WC there were significant differences ($p<0.05$) among distances, excepting the 50 m with respect to the 100 m and 200 m, at the SC there were no differences, perhaps due to the very short SL in the 100 m and 200 m events.
The backstroke was the style where the event distance had least influence in the SI for both genders; the butterfly was the style where the distance most affected the men while this influence was very similar in the remaining styles for the women. Table 1 presents the SI percentage found from the highest SI, in both championships that is the 50 m male freestyle [4.15 $m^2 \bullet (s \bullet cycle)^{-1}$ is 100%].
As a general tendency a reduction of the SI value is appreciated when the event distance increases as much in the men as in the women and in both championships from the 100 m events. The SI values of the man's 50 m backstroke and breaststroke events were smaller than 200 m; in these events, the increase of the SF was not able to compensate the large reduction of the SL and of this way, although the velocity was higher in these events than in superior distance events the SI were not. At the SC the women did not reduce the SL so much in the 50 m events and their SI is in second place of the three distances analysed for style, except in the butterfly that reaches the highest value.

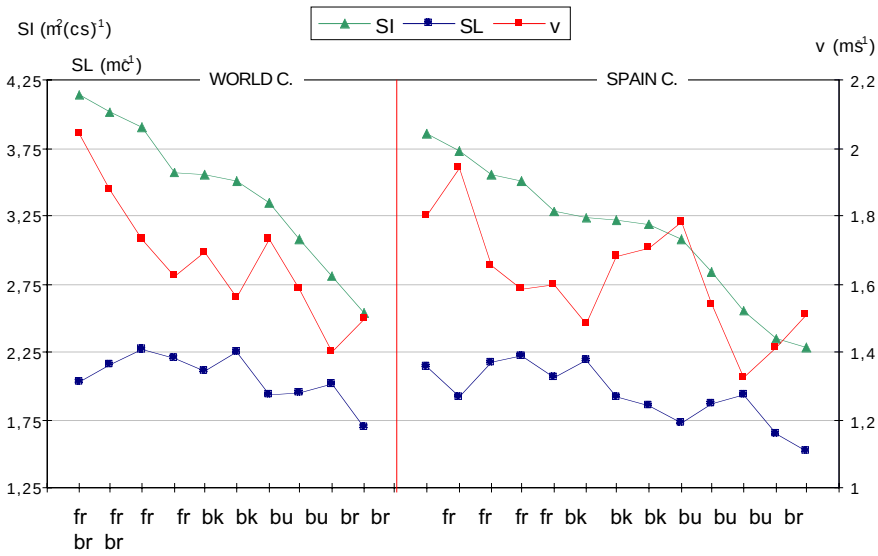


Figure 1. SI, SL and v at the World and Spain Championships male events

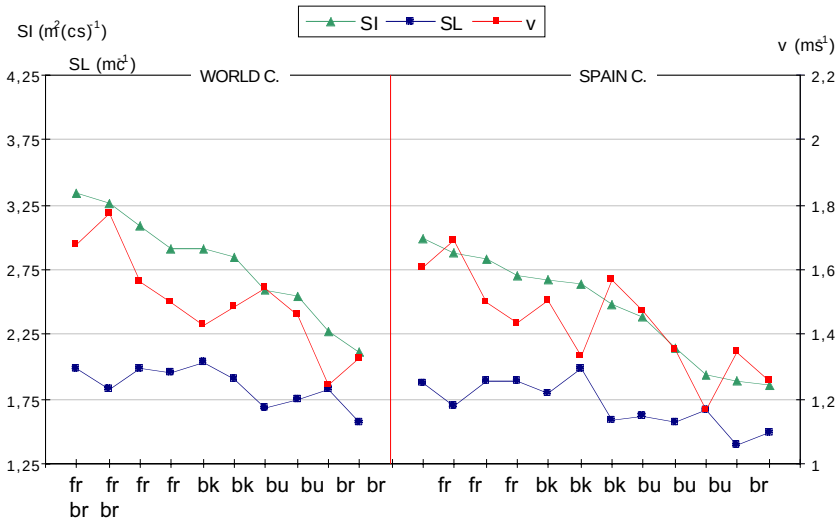


Figure 2. SI, SL and v at the World and Spain Championships male and female events

**Table 1. SI, expressed as a percentage of the maximum value obtained, per event, sex and style, at WS and SC.**

| | Freestyle | | | | | Backstroke | | | | Butterfly | | | | Breaststroke | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 100 | 200 | 400 | **Mean** | 50 | 100 | 200 | **Mean** | 50 | 100 | 200 | **Mean** | 50 | 100 | 200 | **Mean** |
| WC Male | 100 | 97 | 94 | 86 | 94 | | 86 | 84 | 85 | | 81 | 74 | 77 | | 61 | 68 | 64 |
| WC Female | 79 | 80 | 74 | 69 | 76 | | 70 | 70 | 70 | | 62 | 61 | 62 | | 51 | 55 | 53 |
| SC Male | 90 | 93 | 86 | 84 | 88 | 78 | 79 | 78 | 78 | 74 | 77 | 68 | 73 | 55 | 56 | 62 | 58 |
| SC Female | 69 | 72 | 68 | | 70 | 65 | 65 | 64 | 64 | 60 | 57 | 52 | 56 | 45 | 45 | 47 | 46 |

**CONCLUSIONS:** a) SI may be used as indicator of performance level because in the international competition swimmers' SI was significantly greater than in the national competition swimmers SI. b) Results showed an important correlation between SI and FT at both championships in all the butterfly race distances. c) For swimming styles: front crawl had the greatest SI followed by the backstroke and butterfly; the breaststroke SI had the smallest value. d) The general tendency indicates that as the distance of the race increases, from 50 to 400 m, SI decreases, excepting breaststroke style. d) In all the events, without

exception, SI was significantly greater in the male swimmers than female, independently of theirs level.

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