Iranian Journal of Health and Physical Activity (2012) 3 (2), (49-54)

Biomechanical Factors in 200m Freestyle Swimming and Their Relationships with Anthropometric Characteristics

Mohsen Barghamadi[1]*, Zohreh Behboodi[1], Daljit Singh Toor [1]

[1] *Department of Physical Education, Panjab University, Chandigarh, India*

Received 26 April 2012 Accepted 10 September 2012

Abstract

Introduction: The purpose of this study was to determine the relationships between velocity (V), stroke length (SL), and stroke rate (SR) in each 50 meter distance in 200m freestyle competitions and their relationships with anthropometric characteristics.

Material and Methods: The sample consisted of twenty one Indian male inter-university swimmers with mean age of 18.66±1.11 years, mean body mass of 70.04± 1.02, mean height of 177±7.76 cm, mean arm span of 188±8.42cm, mean foot length of 27.28 ± 1.63 cm, and mean body mass index (BMI) of 22.09 ± 2.46 kg/m². All the participants swam and their biomechanical factors were recorded with a video camera (150 Hz) and their time records were recorded using stopwatches at each 50-meter distance.

Results: Correlations showed that there was a significant relationship between SR and V. A significant negative relationship was observed between SL and SR and there were no relationship between the SL and V in 200 meter freestyle swimmers. The results of the stepwise regression technique showed that there were significant differences between velocity and anthropometric characteristics such as standing height, weight, difference of arm span and height and BMI.

Discussion and Conclusion: The V of swimming is governed by SL and SR. The difference between height and arm span may explain the difference in stroke length. SR and SL were thus the main contributors to the higher velocity of the swimmers, since the magnitude of SL is related to the propulsive forces that a swimmer exerts while stroking.

Keywords: Stroke rate, Stroke length, Velocity, Anthropometric characteristics

Introduction

Swimming techniques are the manners in which the swimmer moves cyclically and are determined by competition rules [1, 2]. The performance in swimming, as in other cyclic sports such as cycling and running, has been strongly linked to physiological, technical and physical capacities. But, as water locomotion demands more energy per unit distance compared to the locomotion on land the control of technical level may be important in increasing propulsive force and reducing active drag [3, 4, 5]. A common thread between walking, running, cycling and swimming is that they are all cyclic forms of locomotion. All these forms of locomotion have a rate in which the cycles occur. In running and walking this cycle is called step rate, but it is half of a full cycle and coaches tend to refer to it as stride rate. In cycling it is called cycle rate or cadence. In swimming it is called stroke rate (SR) [6]. Craig and Pendergast [7] found that men and women used different combination of SL and SR to swim at the same velocity. This could be due to many variables such as height, strength, and body composition among others.

Korhonen, Mero, Suominen [8] reported that swimmers appear to behave differently from runners. This can be seen at swimming competition where the older swimmers tend to have a reduced SR during their races. This leads to questions of why the SL-SR relationship with velocity is different for individuals and why it changes with age and anthropometric characteristics. If older swimmers are to train to their potential, it will have to be determined what are the most important factors related to velocity. Typically, journal and magazine articles are based on data from elite twenty-year-old participants so their results may or may not apply to older swimmers as their bodies

* Coresponding author E-mail:
salehbarghamadi@yahoo.com

have changeover time [9].

The velocity (V) of swimming is governed by stroke length (SL) and stroke rate (SR). Different research teams have studied optimal SL/SR ratio according to velocity [7, 10, 12] and the variations introduced by swimming styles [13, 14, 15], by the distance of the race [7, 12, 16, 17] or throughout the course of the race [14]. These authors reported that similar swimming performances are characterized by greater variability in stroke length compared to the stroke rate. Observations made during international competition have shown that the combination of stroke rate and stroke length in producing velocity is highly individual. Among the factor that may influence the relationship between stroke rate and stroke length which affects swimming speed are anthropometric parameters that have been shown to be related to stroke rate and more importantly to stroke length. Specific anthropometric characteristics such as body form and size, surface area of propulsive segments, and floating capacity have been identified by Toussaint [18] Chatard, [6] and Grimston and Hay [21] as factors exerting a great influence on performance and also stroke mechanics. In contrast, previous studies [25, 33] reported weak correlations between anthropometric parameters such as height and final times for both male and female swimmers. Despite the research activity referred to, there appears to be a paucity of information regarding the direct influence of anthropometric characteristics on top-level swimming. The purpose of this study was to determine the relationships between velocity (V), stroke length (SL), and stroke rate (SR) in freestyle competitive male swimmers' results and to assess their relationships with anthropometric characteristics.

Material and Methods

The sample consisted of twenty one male interuniversity swimmers aged between 17 and 22 years who participated in an interuniversity swimming competition. The purposive systematic sampling technique was used. The participants, who consisted of 24 teams, took part in an interuniversity competition of freestyle swimming in 2011; also, the competition took place in a long pool of Panjab University in Chandigarh, India. All the swimmers (with a mean age of 18.66±1.11 years, mean height of 177±7.76 cm, mean arm span of 188±8.42cm, mean foot length of 27.28 ± 1.63 cm, mean body mass of 70.04± 1.02 and mean body mass index (BMI) of 22.09 ± 2.46 kg/m²) had a training background of 9.52 ± 2.82 years, and they had been trained for 23.47 ± 7.42 h/week over the last two years. The swimmers were accessible samples who took part in the study voluntarily.

In order to collect the necessary information, after preparing the form and getting the permission from the department of Sports in Panjab University, Chandigarh, one of the researchers attended the 2011 interuniversity swimming competition and recorded the mentioned variables in the competition. Data collecting involved two phases: 1) measuring the anthropometric characteristics and 2) assessing the biomechanical factors in freestyle swimming. In the first phase, the necessary data were gathered and the research variables were measured based on the pre-planned appointments with the swimmers and coaches. After making sure about the participants' physical and mental health, the researcher measured their anthropometric characteristics based on standard methods. Meanwhile, all the measurements in the present study were done on the right side of the participants by the help of two experts in physical education while the researcher himself directly monitored the measurement process. Before conducting the measurement, the participants were justified and assured about the measurement procedure individually and in groups so that they took part in the study voluntarily and eagerly. In the second part, before the competition started three video recorders were installed in order to measure the biomechanical factors. Two of the cameras were installed half way along the two sides of the pool and the other was installed on the right corner. All the cameras recorded all the competitions and the referee recorded all the times. The recorded tracks were analyzed and reviewed by three experts in the field in a computer set after the competition. In fact, in order to consolidate the data and their validity, the performance of each swimmer was reviewed nine times.

Each of the twenty one swimmers swam and all the events were recorded by three VHS video recorder (Canon, IXUS 220 HS). Velocity was calculated in every event by Hanhart stopwatch (made in Germany). Stroke rate was measured across the length of the pool and expressed in cycles per minute (cycles/Min). Stroke length was calculated, dividing the 50 meters velocity by the stroke frequency (distance/cycles). The age of the swimmers and the anthropometric measurements such as height, arm span, weight and foot length (using a tape Butterfly (made in Japan) and, medical balance scales (made in UK) respectively) were also recorded during the same competition.

Table1: Means and standard deviations of biomechanical factors for swimmers in 200m freestyle in each 50-meter distance

200Freestyle	Stroke length ($m.s^{-1}$)		stroke rate ($cycles.min^{-1}$)		Velocity ($m.cycles^{-1}$)	
	M	SD	M	SD	M	SD
First 50 m	1.24	0.19	1.25	0.19	1.53	0.09
Second 50 m	1.12	0.15	1.19	0.16	1.32	0.08
Third 50m	1.07	0.14	1.20	0.16	1.27	0.10
Fourth 50m	1.04	0.16	1.26	0.20	1.29	0.13
200 Freestyle	1.11	0.16	1.22	0.17	1.35	0.09

Statistical analysis

After entering the data all the statistical analyses were performed using the Statistical Package for Social Sciences (SPSS 17.0). Determining the values for each variable; the following descriptive and inferential statistics were used by the researchers. Means and standard deviations were computed for all the measured variables. Pearson's Product moment correlation coefficient was used to reduce some anthropometric variables. In order to determine the degree of the relationship between biomechanical factors and anthropometric characteristics, one-way factorial analysis of variance (ANOVA) and correlation were used to determine the differences of stroke length (SL), stroke rate (SR) and velocity (V) at different intensities. P-value ≤ .05 was considered to be statistically significant.

Results

Correlations showed that there were significant relationships between SR and V. There was a significant negative relationship between SL and SR and no relationship between the SL and V in 200 meters freestyle swimmers. The post hoc test (Tukey) showed there were significant differences in SR & SL, SR & V and SL &V in 200 meters freestyle swimmers. The results of the stepwise regression technique showed there were significant differences between velocity and anthropometric characteristics such as standing height ($t = -2.86$, $P = 0.01$), weight ($t = 2.94$, $P = 0.01$), difference of arm span and height ($t = -2.29$, $P = 0.03$) and BMI ($t = -2.93$, $P = 0.01$), except for the foot length ($t = 0.95$, $P = 0.35$). In all the comparisons, the significance threshold was set at $P < 0.05$. In the stepwise regression, only the variables that added significance to prediction ($P < 0.05$) were included in the final regression equation.

Table 2: Relationship between stroke rate, stroke length and velocity in 200-m freestyle swimming

	Biomechanical factors	r	Sig
200 m	SR & V	**0.44**	**0.04**
Freestyle	SL & V	**0.10**	**0.66**
swimming	SR & SL	**-0.83**	**0.00**

The mean difference was significant at the .05 level

Discussion and Conclusion

It was evident from figure 1 that in the first 50m part, stroke length, stroke rate and velocity were greater compared to the other 50m distances, as it was just the beginning of the swimming. Ignoring the first 50m part, with an increase in distance, stroke length and velocity decreased, but stroke rate increases; hence, the highest difference between the variables was observed in the fourth 50m distance, and presumably because the competition was near its end.

A broader comparison of these results with the results of the current literature cannot be made, mainly due to the differences of the protocols employed in the anthropometric measures. Other important differences which prevented us from making further comparisons include: gender and the level of performance of the participants, and also the statistical procedures employed in the data analyses.

The following conclusions have been drawn from the results of the present investigation:

1. A correlation prevailed for the variable SR, SL and V.

2. The athletes who use a larger stroke length in the 200 meter freestyle tend to be taller, with longer arms, and heavier and smaller feet.

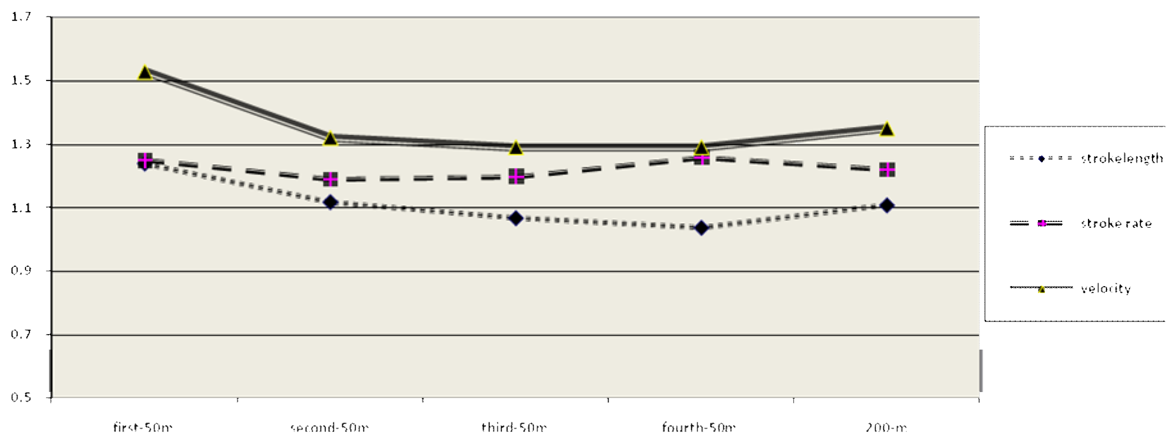

Figure 1: Means of Stroke length, Stroke rate and Velocity, in 200m freestyle swimming

Conclusion

Within the limitations and scope of the study and based on the findings the following conclusions could be drawn from the results of the present study:

Looking at the swimming comprehensively, individual differences observed in the participants in the interuniversity competition were associated with differences in stroke rate, stroke length and velocity. These differences were dependent on the interaction between the biomechanical requisites of the task (swimming techniques) and individual skill. Long distance swimmers were characterized by longer stroke length, and less stroke rate variability.

The velocity of swimming is governed by stroke length and stroke rate. [26] The difference between height and arm span may explain the difference in stroke length. Biomechanical factors can be explained by swimmers' various techniques, strengths and anthropometric characteristics. There was a significant difference between stroke rate and velocity and between stroke rate and stoke length among swimmers. Stroke rate and stroke length were thus the main contributors to the higher velocity of the swimmers, since the magnitude of stroke length is related to the propulsive forces that a swimmer exerts while stroking. [23]

In the end, keeping in mind the fact that biomechanical factors and anthropometric characteristics are vital in sports performance, couches involved in swimming are advised to focus on biomechanical factors specifically stroke rate and stroke length, as well as anthropometrical characteristics in children, for swimmers who have inherited these characteristics are more likely to succeed. Additionally, competitive sports are multi-factorial phenomena; therefore, it is suggested that the coaches consider the swimmers as complex beings and focus on all the factors affecting their success.

References

1-Alberty MR, Potdevin FP, Dekerle J, Pelayo, PP, Sidney MC (2011). Effect of Stroke Rate Reduction on Swimming Technique during Paced Exercise. Journal of Strength & Conditioning Research 25 (2):392-397.

2-Alberty M, Sidney M, Pelayo P, Tooussaint HM (2009). Stroking Characteristics during Time to Exhaustion Tests. Medicine &Science in Sport & Exercise 41 (3):637-644.

3-Andrew D, Sortwell (2011). Relationship between Stroking Parameters and Leg Movement Quantity in 100 Metre Front Crawl. International Journal of Exercise Science 4 (1):22-29.

4-Barbosa TM, Marinho DA, Costa MJ, Silva AJ (2011). Biomechanics in Applications (Vols. 16-Biomechanics of Competitive Swimming Strokes). InTech Citation.

5-Barden JM, Kell RT (2009). Relationships between stroke parameters and critical swimming speed in a sprint interval training set. Journal of Sports Sciences 27 (3):227-235.

6-Chatard J, Wilson B (2003). Drafting distance in swimming. Medical and science in sports and exercise 35:1176-1181.

7-Craig A J, Pendergast D (1979). Relationship of stroke rate, distance per stroke and velocity in competitive swimming. Medicine and Science in sports and Exercise 11 (3):278-283.

8-Korhonen MT, Mero A, Suominen H (2003). Age-Related Differences in 100-m Sprint Performance in Male and Female Master Runners. Medicine & Science in Sports & Exercise 35 (8):1419-1428.

9-Morriso B, Hinrichs R, Larsen B (2005). The effect of aging on stroke parameters in swimming. 20th International Society of Biomechanics, (p. ASB 29th Annual Meeting). Cleveland, USA pp:936.

10-Craig AJ, Skehan P, Pawelczyk J, Boomer W (1985). Velocity, stroke rate, and distance per stroke during elite swimming competition. Medicine and Science in sports and Exercise , 17 (6):625-34.

11-Daniel A, Marinho, Abel I, Rouboa (2010). Modelling Swimming Hydrodynamics to Enhance Performance. The open sport science journal 3:43-46.

12-East D (1970). Swimming: An analysis of stroke frequency, stroke length and performance. New Zealand Journal of Health. Physical Education and Recreation 3:16-27.

13-Changalur S, Brown P (1992). An analysis sof male and female Olympic swimmers in the 200-meter events. Canadian Journal of sports Science 17 (2):104-109.

14-Hay J (2002). Cycle Rate, Length, and Speed of Progression in Human Locomotion. Journal of Applied Biomech 18 (3):257-270.

15-Kennedy P, Brown P, Chengalur S, Nelson R (1990). Analysis of male and female Olympic swimmers in the 100-meter events. International Journal of Sport Biomechanics 6:187-197.

16-Keskinen K, Komi P (1993). Stroking characteristics of front crawl swimming during exercise. Journal of Applied Biomechanics 9:219-226

17-Pelayo P, Dekerle J, Delaporte B, Gosse N, Sidney M (2008). Critical Speed & Critical Stroke Rate Could be Useful Physiological and Technical Criterial for Coaches to Monitor Endurance Performance in Competitive Swimmers. CoachesInfo.com-information and education for coaches.

18-Toussaint, Beek (1992). Biomechanics of competitive front crawl swimming. Sports Medicine 13 (1):8-24.

19-Latt E (2010). Physiological, biomechanical and anthropometrical predictors of sprint. Journal of Sport Science and medicine 9:398-404.

20-Gourgoulis V (2010). Kinematic characteristics of the stroke and orientation of the hand during front crawl resisted swimming. Journal of Sport Sciences 28 (11):1165-1173.

21-Grimston SK, Hay JG (1986). Relationships among anthropometric and stroking characteristics of college swimmers. Medicine & Science in Sports & Exercise 18 (1):60-68.

22-Hay JG (1993). The Biomechanics of Sports Techniques.Publisher: Prentice Hall, pp:205-231.

23-Jesus S, Costa M, Marinho D, Garrido N, Silva A, Barbosa T (2011). 13th FINA World Championship finals:stroke kinematics and race times according to. Portuguese Journal of Sport Science 11:275-278.

24-Jorgic B, Aleksandrovic M, Okicic T, Madic D (2009). The influence of flexibility onto the swimming results in students of sport and physical education. Sport Science 2 (1):91-94.

25-Katch V (1973). The relationship between segmental leg measurement, leg strength, and relative endurance performance of females. Human Biology 45:371-383.

26-Katz J, Bruning NP (1993). Swimming for Total Fitness. Publisher: Doubleday.

27-Osborough C, Payton C, Daly D (2009). stroke parameters arm coordination in competitive unilateral arm amputee front crawl swimming. 27 International Conference on Biomechanics in Sports.

28-Pelayo P, Sidney M, Kherif T (1969). Stroking Characteristics in Freestyle Swimming and Relationships with Anthropometric Characteristics. Journal of applied biomechanics 12:197-206.

29-Popo A, Dedovic D, Likic S, Mulaosmanovic S (2010). Relations between some morfological dimensions and a achivement in swimming of young swimmers representatives of b&h. Acta Kinesiologica 4 (1):67-70.

30-Schnitzler C, Seifert L, Alberty M, Chollet D (2010). Hip Velocity and Arm Coordination in Front Crawl Swimming. International Journal of Sports Medicine

31 (12):875-881.
31-Seifert L, Toussaint H, Alberty M, Schnitzler C, Chollet D (2010). Arm coordination, power, and swim efficiency in national and regional front crawl swimmers. Human Movement Science 29:426-439.
32-Smith LE (1978). Anthropometry Related to Speed. J Sports Med Phys Fit 18 (2):153-168.
33-Stallman RK, Kjendlie PL (2006). The stroke length, frequency and velocity among university physical education students and its use as a pedagogical tool. Biomechanics and Medicine in Swimming 10:268-270.
34-Strzala M, Tyka A (2009). Physical endurance, somatic indices and swimming technique parameters as determinants of front crawl swimming speed at short distances in young swimmers. Medicina Sportiva 13:99-107.