COMPARISON OF 50 METERS FREESTYLE RACE COMPONENT TIME ANALYSES OF PAKISTANI AND INTERNATIONAL SWIMMERS

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***ABSTRACT*:** *Present study presents the comparative time (sec) analysis of race components (RCs) between male swimmers (n=8) participated in European Swimming Championship held in Debrecen, Hungary from May 14-27, 2012 (http://swim.ee) and male swimmers (n=24) from National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014. For 50 meters freestyle event, race components (RCs) of Pakistani swimmers were monitored with the help of digital video cameras installed at the distance(m) 5, 15, 25 and 45 from starting point at the Pakistan Sports Board swimming pool Islamabad. Total race time (RT) was divided into six race components (RCs) i.e. Surface Break Point (SBP), Starting Time (ST), Split Time 25 (ST_1), Split Time 45 (ST_2), Stroking Time (ST_3) and Finishing Time (FT). The correlation of RT with ST, ST_2, and ST_3 was significant ($p<0.01$) while insignificant with SBP, ST_1 and FT for both Pakistani and International swimmers. The comparison between Pakistani and International swimmers, by applying t-test, ANOVA and Regression analysis, revealed a significant ($p<0.01$) difference in mean times of all RCs as well as in average velocity (0.41 ms^{-1}). The average velocity of Pakistani swimmers was 1.84±0.06 ms^{-1} that was 0.41 ms^{-1} less than the international swimmers. The prediction models for ST, ST_2 and ST_3 for Pakistani swimmers on the basis of RT were significant ($R^2 \geq 0.82$, $p<0.01$) whereas they were non-significant for SBP and ST_1. Similarly, the prediction model for FT was also significant ($R^2=0.62$, $p<0.05$). The results can be used as a benchmark for young Pakistani swimmers and their coaches to identify weak race components for focused training.*

Keywords: 50 meters, free style, race component time analysis, Pakistani and European Swimmers.

INTRODUCTION

Analysis of race components in swimming competitions has been utilized to provide swimmers and coaches with a concise and clear summary of every event in a swimming contest. The analysis was used to identify the relative strengths and weaknesses of swimmers, so that the weaknesses may be improved by specialized and focused training. It was used by coaches of elite swimmers primarily to develop and then refine a competition model for a swimmer [1].

For analysis of swimming competitions [2] divided total race time into four parts called Race Components (RCs) i.e. 1. Time spent starting (ST), 2. Time spent stroking (CT), 3. Time spent turning (TT) and 4. Time spent finishing (FT). [3] analyzed the swimming competitions by using same four race components. As this study was carried out on the 50m swimming pool for 50m freestyle swimming race event, therefore there was no turning and hence no turning time (TT). In addition to the remaining 3 race components, the author has added 3 more race components in this study for detailed analysis. These additional race components are surface breakpoint (SBP), ST_1 (time taken from 15m to 25m) and ST_2 (time taken from 25m to 45m) making a total of 6 race components.

To know the strengths and weaknesses, sports researchers have been focusing the race components of competitive swimmers in different countries over the period of time, like [3,4,5].

Significant amount of research work has been carried out by [3,4,6,7] with emphasis on the importance of race components for elite swimmers. The authors showed that study of RCs can be used to find out the weakest RC of a swimmer and hence the results can be used for specific and focused training, for improvement, resulting in performance enhancement of swimmer. They further analyzed RCs data of elite swimmers and concluded that this data can be utilized as bench mark by the coaches or by the swimmers themselves for their performance evaluations and trainings. In this way the coaches will understand not only race target time but also race components target time. The authors took another step further in this direction by providing a mathematical modal [7] of RCs of elite swimmers participated in Olympic Games 1992. The mathematical model provided A (slope) and B (y-intercept) with significance ($p<0.01$) for calculation of RCs (RC = [A.Race Time] + B) for different styles of swimming competitions. This model was used by coaches to compare RCs of trainees with that of elite swimmers.

In a similar work [8] emphasized that coaches should give particular importance to individual RCs in training programs. [9] further reported that a decrease of 0.13 seconds in starting time had an impact of 4.9%, a decrease of 1.6 seconds in mid-pool swimming time contributed about 60.4% and a decrease of 0.89 seconds in turning time shared 33.6% in a decrease of a total of 2.65 seconds in mean finishing time.

Another study was carried out by [10] analyzing RCs of a famous swimmer Ion Thorpe (Australia) with that of other swimmers. The authors employed cluster analysis to formulate a mathematical model of RCs of swimmers participated in Sydney 2000 and suggested that analysis of RCs can provide significant guidelines for coaches in developing training programs.

The research work of Arellano inspired Morales to conduct a similar study in Spain. [4] analyzed the RCs of different age group swimmers to formulate a mathematical model based on regression analysis which provided a percentage of RCs with respect to the age of swimmer. The authors then compared the resulting RCs of the model with those of elite international swimmers. The comparison revealed that the young swimmers have a tendency to get the timings of their RCs close to those of elite swimmers with differences less than 0.4 seconds in all individual race components.

A study was conducted on the same pattern by [5] on Chinese elite swimmers performed in 29th Olympics 2008, 14th FINA World Championships 2011 and the 11th

National Games 2009 in China. Their analyses highlighted the advantages as well as discrepancies and short comings in RCs of Chinese swimmers as compared to international elite swimmers.

It was highlighted by [11] that study of race components provides valuable information in competitive swimming. The authors compared national swimmers with regional swimmers and concluded that national swimmers outperform regional swimmers with higher underwater velocities (0.30 ms^{-1}) and constant turning times (8.88 sec).

In a similar work, [12] studied the race components of elite swimmers for 100 meters freestyle finalists at Beijing Olympics 2008, London Olympics 2012, FINA World Championship Montreal, Canada 2005, FINA World Championship Melbourne, Australia 2007, FINA World Championship Rome, Italy 2009, FINA World Championship Shanghai, China 2011 and FINA World Championship Barcelona, Spain 2013. The author calculated each RC as percentage of the total race time and compared the time profiles of male swimmers with female swimmers showing significant differences ($p<0.001$) in first and last 25 meters of competition. The author further noted that female finalists of 2013 were faster by 1.27 seconds than from 2005.Likewise, male finalists of 2013 were 0.67 seconds faster than from 2005 with a significant improvement of 0.19 seconds in turning time.

In another study, [13] observed variance in selected race components of elite swimmers with training experience greater than 10 years. Similarly, [14] compared RCs in individual and relay events and came to the conclusion that individual RCs have a significant impact ($p<0.001$) on the race outcome.

The correlations of race components were analyzed by [15] in 100 meters freestyle event with the total race time. The authors applied linear regression analysis to formulate mathematical models ($p<0.001$) for prediction of total race time from race components.

In a similar research, [16] carried out a study on pacing strategies of elite swimmers by observing their race components above water and underwater. The authors analyzed that with the passage of race, the velocity of swimmers on water surface was reduced by 0.12 ms^{-1} while the underwater velocity remained almost constant. So, the coaches were advised to devise a strategy for both underwater and surface race components.

In a recent research, [17] studied the practices being used for the performance study of elite swimmers. The authors pointed out that more than 70% of coaches are using video-based techniques for the qualitative and quantitative analysis of swimmers' performance.

A comprehensive study was conducted by [18] on performance comparison of swimmers in World Championships (1994–2013) and Olympic Games (1992–2012) using different techniques including multi-level regression analyses and showed that young swimmers benefit from training in longer race distances (200m & above) before they change to shorter distances (50m and 100m).

The present study is first of its kind that highlighted the importance of analyzing race components, using different biomechanical approaches, of Pakistani swimmers and comparing them with their international counterparts. So far, no such study has been carried out in Pakistan. This study will provide insight into weaker and stronger areas of Pakistani swimmers and also serve as a reference for the coaches to focus their training accordingly.

MATERIALS AND METHODS

Twenty-four Pakistani male swimmers who qualified for the finals of National Swimming Championship 2014 held in Islamabad, Pakistan, and eight international male finalist swimmers, participated in European Swimming Championship 2012, for 50m freestyle competition, were included in this study.

The present study was conducted with the help and permission from Pakistan Swimming Federation (PSF) and Pakistan Sports Board (PSB) during the National Swimming Championship 2014, Pakistan. All the visuals of the event were recorded with the help of 4 motion picture cameras (Sony HDR-HC9E) and the videos were synchronized with the official timings recorded by Omega. All the distances were recorded from the perpendicular plane of the swimmer's position at a distance of 6 meters from the pool [4]. Cameras designated as 1, 2, 3 and 4 were positioned at 5, 15, 25 and 45 meters respectively from the starting point.

The data obtained from Pakistani swimmers (n=24) was compared with the data obtained from the website [http://swim.ee] for European Swimming Championship 2012 finalists (n=8). A software Kinovea [19] was used to calculate/analyze race components, from the data captured by video cameras by imposing digital lines on the video playback at 15, 25 and 45 m with the help of pool side calibration marks [8]. The analysis of present data was done with help of the software provided time values for following 6 Race Components:

1. Surface Break-Point Time (SBP) – time (sec) at which a swimmer's head breaks surface of water after underwater dive from starting of race.
2. Starting Time (ST) – time (sec) at which the head of swimmer passes through 15 meters interpolated line from starting of race.
3. Split Time 25m (ST_1) – time (sec) at which the head of swimmer passes through 25 meters interpolated line from 15 meters mark.
4. Split Time 45m (ST_2) – time (sec) at which the head of swimmer passes through 45 meters interpolated line from 25 meters mark.
5. Stroking Time (ST_3) – time (sec) at which the head of swimmer passes through 45 meters interpolated line from 15 meters mark.
6. Finishing Time (FT) – time (sec) taken by swimmer from 45 meters interpolated line to finishing line.

In addition to the above provided race components, the total time (sec) taken by a swimmer from the starting of race to finishing line is called Race Time (RT) and the value obtained by dividing the total distance (50m) by Race Time is referred to as Average Velocity (AV).

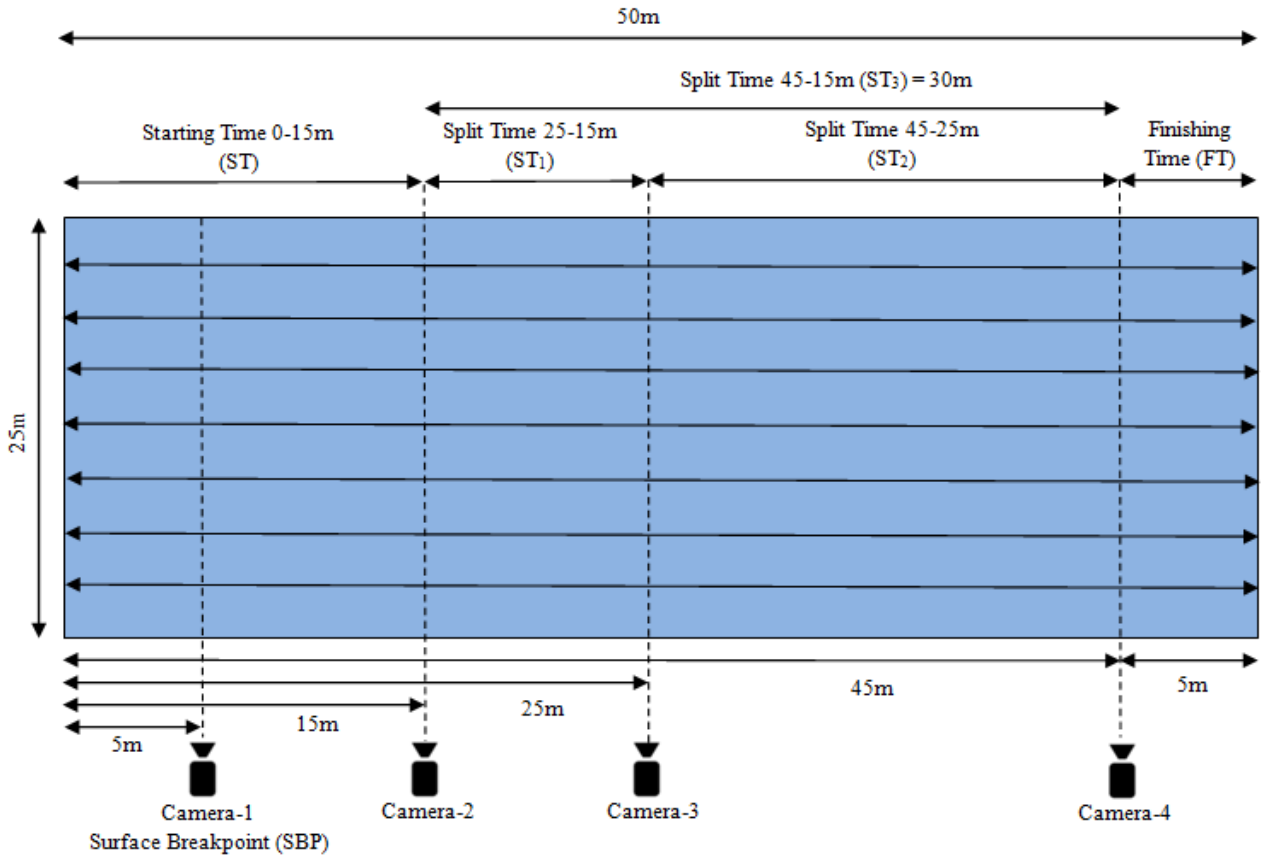

Fig. 1: Figure showing the camera installations at 5, 15, 25 and 45 meters distance on 50m swimming pool at Pakistan Sports Board (PSB) swimming pool Islamabad, Pakistan. The distances for race components are also shown in the above figure.

All the race components of Pakistani and the European Union summers were compared by using SPSS 19.0 statistical software (SPSS Inc., Chicago, III., USA.). The regression analysis was used to find out prediction models to calculate SBP, ST, ST1, ST2, ST3 and FT on the basis of RT.

STATISTICAL ANALYSES

Shapiro-Wilk test was applied to the data [20]. Mean, standard deviation and coefficient of skewness were used to obtain a descriptive analysis of all the components. Coefficients of correlation were calculated to analyse the relationship between Pakistani and European Union swimmers' race components. T-test for independent samples (with unequal variance) was applied to compare the performance of Pakistani and European Union swimmers. Simple regression analysis was used to find out the prediction models for race components on the basis of race time. ANOVA was used for model significance at 99% & 95% level of confidence.

RESULTS AND DISCUSSIONS

Table 1: Showing descriptive statistics of Race Components (RCs) of male swimmers (n=8) of European Swimming Championship held in Debrecen, Hungary from May 14-27, 2012; and male swimmers (n=24) from National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014.

Sr.#	Race Components	Mean ± S.D. (time in sec)		Coefficient of Skewness	
		Pak (n=24)	Int (n=8)	Pak (n=24)	Int (n=8)
1	SBP	2.53 ± 0.33	3.36 ± 0.59	-0.13	0.57
2	ST	6.83 ± 0.34	5.61 ± 0.01	0.70	0.35
3	ST_1	5.31 ± 0.27	4.66 ± 0.06	-0.05	0.00
4	ST_2	12.26 ± 0.44	9.83 ± 0.09	1.61	-0.38
5	ST_3	17.57 ± 0.55	14.49 ± 0.14	1.38	-0.23
6	FT	2.75 ± 0.17	2.09 ± 0.07	1.05	-0.74
	RT	27.16 ± 0.95	22.20 ± 0.24	1.72	0.40
	AV	1.84 ± 0.06	2.25 ± 0.02	-1.62	-0.31

SBP = Surface Breakpoint, ST = Starting Time, ST_1 = Split Time 15-25m,
ST_2 = Split Time 25-45m, ST_3 = Stroking Time 15-45m, FT = Finishing Time 45-50m, RT= Total Race Time, AV = Average Velocity, Pak = Pakistan, Int = International

The average time, standard deviation and coefficients of skewness of race components (Table 1) showed that mean times of Pakistani swimmers for all variables were less than the mean times of international swimmers except SBP. The S.D. indicated that Pakistani Swimmers were less consistent than international swimmers at all points except SBP. Results showed that larger the distance covered during race, higher the SD. A huge variation was found among the Pakistani swimmers performance. Coefficients of skewness showed that the overall distribution of RCs of Pakistani swimmers was slightly negatively skewed while distribution of RCs of international swimmers was close to symmetry. As the race components get better with lower values, so the coefficients of skewness were used with opposite sign (positive coefficients shown as negative and vice versa). Average velocity (AV) of Pakistani swimmers was 1.84 ms^{-1} which was 0.41 ms^{-1} less than international swimmers. [3] conducted their study on Sydney Olympics 2000 semi finalist swimmers (n=16) and calculated mean time and standard deviation as 25.36±0.55 seconds whereas mean time and standard deviation of Pakistani swimmers (n=24), in this study, was 27.16±0.95 seconds which is about 1.8±0.40 seconds slower. It is suggested that the main factors contributing to this huge difference in performance include lack of scientific coaching and training, improper use of techniques, non-availability of professional training facilities, relatively young age of swimmers and lack of research and study on the subject.

Correlation Matrix

Table 2: Correlation Matrix of RCs male swimmers (n=24) of National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014 and male swimmers (n=8) of European Swimming Championship held in Debrecen, Hungary from May 14-27, 2012.

Sr. #	Race Components	Categories	SBP	ST	ST_1	ST_2	ST_3	FT	RT
1	SBP	Pak	1	-0.09	-0.80*	0.068	0.45	0.05	-0.23
		Int	1	-0.83*	-0.37	-0.73*	-0.64	0.22	-0.67
2	ST	Pak		1	0.2	0.83*	0.76*	0.6	0.91**
		Int		1	0.53	0.87 *	0.79*	-0.01	0.89**
3	ST1	Pak			1	0.11	0.59	-0.11	0.39
		Int			1	0.72 *	0.89**	-0.24	0.68
4	ST2	Pak				1	0.87**	0.71*	0.92**
		Int				1	0.96**	0.07	0.96**
5	ST3	Pak					1	0.53	0.95**
		Int					1	-0.05	0.91*
6	FT	Pak						1	0.71
		Int						1	0.27
RT		Pak							1
		Int							1

*Significant (p< 0.05), **Significant (p<0.01)

SBP = Surface Breakpoint, ST = Starting Time, ST_1 = Split Time 15-25m, RT= Total Race Time

ST_2 = Split Time 25-45m, ST_3 = Stroking Time 15-45m, FT = Finishing Time 45-50m

Pak = Pakistan, Int = International

The Table 2 indicated that all the RCs of Pakistani swimmers were correlated positively with RT except SBP which had a negative correlation. The correlation of RT with ST, ST_2 and ST_3 was significant (p<0.01). The correlation of SBP with all other RCs was insignificant except with ST_1 which was negative. The ST_3 and RT were highly correlated (r = 0.95) with each other as compared to the correlation among other race components. Table 2 also showed for international swimmers that the SBP was inversely correlated with all other RCs except with FT and its correlation was significant only with ST and ST_2 while insignificant with ST_1, ST_3, FT and RT. The RT variable was significantly correlated with ST, ST_2 and ST_3. The variable ST_2 was highly correlated (r=0.96) with ST_3 and RT. The correlation pattern between RT and RCs for both Pakistani and international swimmers was almost same.

Average Velocities (AV)

It was evident from Fig. 2 that average velocity of international swimmers was considerably high at the start and end of the race. So, it can be safely concluded that Pakistani swimmers were neither efficient starters nor good finishers. Pakistani swimmers also struggled to maintain their velocities between 25 meters to 45 meters as opposed to international athletes.

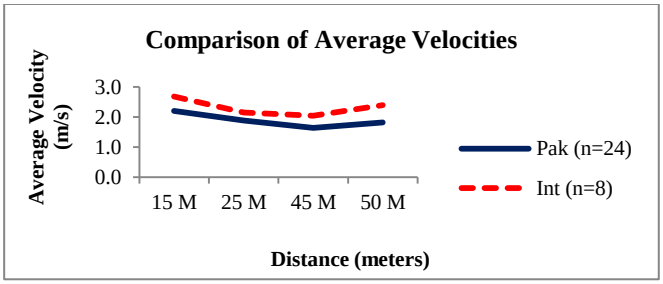

Fig. 2: Comparison of Average Velocities at 4 points of male swimmers (n=8) of European Swimming Championship held in Debrecen, Hungary from May 14-27, 2012; and male swimmers (n=24) from National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014.

Race Components (RCs)

The analysis revealed variation in difference between race components of national and international swimmers. Mean SBP of International athletes was 0.83 seconds higher than Pakistani swimmers. Therefore, Pakistani swimmers need to be trained specifically to improve this timing. Pakistani swimmers can improve their starting time (ST) by increasing their SBP time. Starting time (ST) difference was 1.22 seconds. Upon comparison of Split time 25-45 meters (ST_2) and Stroking time 15-45 meters (ST_3) there was a significant difference of 2.43 and 3.08 seconds respectively. In Split time 15-25 meters (ST_1) and Finishing time (FT), the difference was 0.65 and 0.66 seconds respectively.

SBP (sec) = Surface Breakpoint, ST (sec) = Starting Time, ST_1 (sec) = Split Time 15-25 m, ST_2 (sec) = Split Time 25-45m, ST_3 (sec) = Stroking Time 15-45m, FT (sec) = Finishing Time 45-50m, RT (sec) = Total Race Time

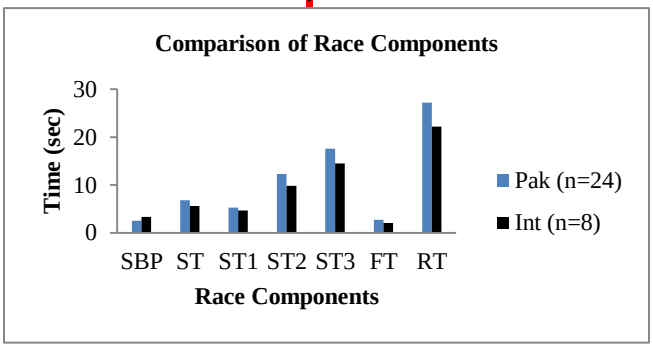

Fig. 3: Average Race Components' time of male swimmers (n=8) of European Swimming Championship (International) held in Debrecen, Hungary from May 14-27, 2012; and male swimmers (n=24) from National Swimming Championship (Pakistani) held in Islamabad, Pakistan from June 13-15, 2014.

Comparison of Race Components Mean Time (Independent t-test)

Table 3: t-test for independent samples of male swimmers (n=8) of European Swimming Championship held in Debrecen, Hungary from May 14-27, 2012; and male swimmers (n=24) from National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014, (with unequal sizes and variances).

Sr.#	Race Components	Categories	Mean Time (sec)	Difference (sec)	S.E.	t-values	P-values
1	SBP	Pak	2.53	-0.83	0.11	-3.59	**
		Int	3.36		0.21		
2	ST	Pak	6.83	1.22	0.12	9.74	**
		Int	5.61		0.04		
3	ST1	Pak	5.31	0.65	0.10	6.54	**
		Int	4.66		0.02		
4	ST2	Pak	12.26	2.43	0.16	15.07	**
		Int	9.83		0.03		
5	ST3	Pak	17.57	3.08	0.19	15.38	***
		Int	14.49		0.05		
6	FT	Pak	2.75	0.66	0.06	9.7	**
		Int	2.09		0.03		
AV		Pak	1.84 ms^{-1}	-0.41 ms^{-1}	0.02	-17.45	**
		Int	2.25 ms^{-1}		0.01		
**Significant (p<0.01), ***Significant (p<0.001)							

SBP = Surface Breakpoint, ST = Starting Time, ST_1 = Split Time 15-25m, RT= Total Race Time
ST_2 = Split Time 25-45m, ST_3 = Stroking Time 15-45m, FT = Finishing Time 45-50m
AV = Average Velocity, Pak = Pakistan, Int = International

The analysis in Table 3 depicted that the RC times of male swimmers (n=24) of National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014 were compared with international male swimmers (n=8) of European Swimming Championship held in Debrecen, Hungary from May 14-27, 2012 with unequal sample sizes and population variances. It was found that there were significant (p<0.01, 0.001) differences in all RCs and AV. The difference was mainly due to improper training in initial diving of Pakistani swimmers

Surface Breakpoint time of international swimmers was also higher contributing in their better starting velocities. The data comparison also showed that Pakistani swimmers were not able to maintain their stroking velocities of the race from 15m to 45 m. The performance of Pakistani swimmers was very poor as compared to international swimmers in all RCs. It was noted that in all cases the values of the standard error of estimate (S.E.) were very low indicating that estimated values were adequate.

Regression Analysis

Table 4: Simple Linear Regression Estimates and ANOVA for prediction Mathematical models of male swimmers (n=24) from National Swimming Championship held in Islamabad, Pakistan from June 13-15, 2014.

Model #	Prediction Models	R^2	S.E.	F	P-values
1	SBP = 4.34 - 0.07 RT	0.04	0.33	0.26	NS
2	ST = -1.95 + 0.32 RT	0.82	0.16	27.74	***
3	ST_1= 2.27 + 0.11 RT	0.15	0.27	1.03	NS
4	ST_2= 0.49 + 0.43 RT	0.85	0.19	34.60	***
5	ST_3= 2.76 + 0.55 RT	0.90	0.19	51.03	***
6	FT = - 0.81 + 0.13 RT	0.62	0.14	5.95	*
Predictors: (Constant), Total Race Time (RT) in seconds.					

SBP = Surface Breakpoint, ST = Starting Time, ST_1 = Split Time 15-25m,
ST_2 = Split Time 25-45m, ST_3 = Stroking Time 15-45m, FT = Finishing Time 45-50m

The regression analysis was used to find out the prediction mathematical models for SBP, ST, ST_1, ST_2 and ST_3 on the basis of RT. It was concluded that the prediction models 1 and 3 for SBP and ST_1 respectively were insignificant because the values of R^2 were very small in both cases (Table 4). So, the prediction or forecasting of SBP and ST_1 times of Pakistani swimmers on the basis of RT will not be statistically appropriate.

The prediction mathematical models 2, 4 and 5 (Table 4) for ST, ST_2 and ST_3 respectively were significant ($p<0.001$) while model 6 for Finishing Time (FT) was significant ($p<0.05$). These models were good fit because the values of R^2 were 0.82, 0.85, 0.90 and 0.62 respectively. This indicated that the 82%, 85%, 90% and 62% variation in variables ST, ST_2, ST_3 and FT respectively might be concluded on the basis of RT.

In a similar research, [7] studied RCs of elite swimmers participated in Olympic Games 1992 and proposed regression based mathematical models ($p<0.01$) for prediction of ST, Stroking Time and FT. The mathematical models formulated in this study for prediction of ST, ST_2 and ST_3 were significant at $p<0.001$ while for FT, the significance was $p<0.05$ as shown in Table 4. This indicated that the mathematical models during this study were more significant ($p<0.001$) than the models ($p<0.01$) formulated by [7] except for FT whose significance found less ($p<0.05$) in this study.

CONCLUSION

Results of race component analysis of competitive swimming event for 50m freestyle race indicated that ST, ST_2, ST_3 and FT had a significant influence on swimming performance for Pakistani top level swimmers. In addition, the mathematical models, based on race components, in this study, will help in providing swimmers and coaches a criteria that will have application for improving coaching strategies for evaluating pace in each phase of 50m freestyle swimming event.

The purpose of this study was to provide an analysis to Pakistani elite swimmers and coaches by analyzing race components of Pakistani and international swimmers. This analysis can also be beneficial for young and upcoming swimmers.

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