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FINAL RESULT PREDICTION IN FEMALE 400M TRACK EVENT BASED ON RESULTS ACHIEVED AT CERTAIN RACE SEGMENTS

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Abstract: *The main aim of this research study was to determine the influence of 6 predictor variables, related to split times at every 100m of 400m race as well as of first and last 200m of 400m race, on criterion variable - final result in 400m event. Entity sample included 32 results from 26 female athletes who were participants of final 400m races at four World Championships in Athletics: Stuttgart (1993), Athens (1997), Seville (1999) and Berlin (2009). Data needed for this research study were obtained from official results and published biomechanical analyses. Multiple regression analysis revealed very high influence of predictor variables on criterion variable, that is – on final 400m result, with 99% of shared variance at the p level of 0.01. Observation of partial coefficients and split times at every 100m showed the best correlation to final result was split running time from 300th to 400thm, as well as running time of both 200m segments of 400m race, especially the second 200m. It can be concluded that all predictor variables are significant for successful placement in 400m race, which proves that even though 400m event is a sprint event, it still requires from runners highly developed abilities such as speed, speed endurance, strength, technique and tactics, mental stability and motivation to fight one self and other competitors in final segments of the race which places 400m event among the most demanding athletic events.*

Keywords: *athletics, 400m sprint, women, running dynamics.*

1. Introduction

In times when male sprinters ran 400m above 47s and female sprinters above 54s, this event was considered to be middle distance event. However, elite female sprinters who run entire lap full strength have turned 400m event into continuous incessant running throughout the entire distance. For this reason, today it is

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characteristic for female sprinters to run 400m event in under 50s. Sometimes the 400m sprint event is also referred to as the "killer event" (Quercetani, 2005) due to the fact that its demands push the limits through which a well-trained runner can maintain his or her maximum speed, and a huge stress being placed on the organism with the body invariably fatiguing, "rigging" or "tying up", especially in the closing stage (Neuhoff, 1978). 400m running demands of female sprinters great conditioning preparation, high level of running technique and appropriate level of motor abilities such as: speed, speed endurance and strength (Homenkov, 1977). 400m event also requires great energy expenditure which consequentially bears great tiredness, stress, pain sensations which are the most pronounced in last segments of the race. In order to achieve best possible result, it is necessary to optimally distribute strength during entire race in a way that the best possible results are achieved at particular segments of the 400m race.

Running analyses have showed that majority of elite 400m sprinters achieve faster times, by 1.5-2s, in the first 200m, compared to second 200m. These runners are of, so called "sprinter type". Still, there are sprinters who achieve somewhat better times in second 200m of 400m race, which evidences their high levels of speed endurance (Gagua, 2001; Šesterova and Šuteeva, 2005).

Previous research studies have proposed that 400m runners, who are mostly of medium height and physically strong, are divided into two different categories (Schiffer, 2008). One category includes those runners who are speed based, and other category includes runners who are speed endurance based. It was also recommended that those two categories of runners have different tactical approach to 400m race. The runners who belong in "speed base" category are supposed to be faster in first 200m after which they maintain running speed for as long as possible, hoping the tiredness will not slow them in race finish. On another hand, runners who have a base of speed endurance run 400m differently, in more even tempo. Their accomplished time in first 200m is very similar to time in second 200m. However, the gathered data from Olympic Games in Mexico City in 1968 show that not a single race has been run in which the second 200m were faster than the first 200m (Arnold, 1989).

Considering further research studies, Gajer, Hanon and Thepaut-Mathieu (2007) have studied parameters of speed and stride frequency in 400m event. According to them, the success in 400m event requires from runner to maintain his optimal stride technical characteristics despite the intensive tiredness. By studying 50m intervals, the authors valued parameters of speed and stride (length and frequency) for races on three levels of competition: world, national and regional. Their results showed that more successful sprinters can achieve greater values of absolute and relative speed, observed through percentage of their best 200m performance. The authors claimed that this was possible equally due to stride length and frequency. It is significant that the best values for those two parameters were observed in different segments of the race: between 50m and 100m for stride frequency and between 100m and 150m for stride length. In general, it is the parameter of stride length, not frequency, where different groups of subjects differ.

Since the morphological measures of subjects were similar, this could imply on greater strength values in runners who achieved better result.

Pelemiš et al. (2013) tried to establish correlation between morphological characteristics and running speed in 100m and 400m for both genders. Regression analysis for male sprinters showed statistically significant correlation of anthropometrical variables with criterion variable - 100m sprint, where the greatest percentage of shared variability was observed; 72%. In 400m sprint shared variability was 33%. From all anthropometrical variables, only height showed statistically significant correlation with criterion variable.

The main purpose of this research study was to determine the influence of predictor variables, related to split times at every 100m and split times at first and last 200m, on criterion variable - final 400m race result in female athletes.

2. Research Methods

Subjects' sample

Entity sample was deliberate and representative, comprised of 32 results from 26 female sprinters (average age: 27.03±3.33 years; average height: 172.73±4.16 cm; average weight: 61.59±4.25 kg) who participated in the finals of World Championships in Athletics in: Stuttgart (1993), Athens (1997), Sevilla (1999), and Berlin (2009) and for whom official results of time parameters of running dynamics in 400m event were available. Data used in this research study were extracted from official results' list and results of biomechanical analyses published on internet web page of IAAF and book by Joch, W. (1997) "Sprint".

3. Variables' Sample

Variables' sample for this research study consisted of 7 variables: 4 predictor variables related to split times at every 100m, 2 predictor variables related to first and second 200m of 400m event and criterion variable – result, related to final 400m race time.

4. Data Analysis

Multiple regression analysis was used to determine level of correlation between group of predictor variables (split times at every 100m and split times at first and second 200m) and criterion variable (Result). Partial coefficients values were used to determine influence of individual 400m race segments on 400m event final result. P level was set at $p<0.01$. All data analyses were done at Faculty of Kinesiology in Zagreb with program package Statistica ver. 13.3.

5. Results and Discussion

Table 1 shows original results of female sprinters who participated in finals of World Championships in Athletics between 1993 and 2009.

Original results of 100m and 200m segments of 400m event Table 1

	0-100	100-200	200-300	300-400	0-200	200-400
Jearl Miles-Clark	12.43	11.52	12.38	13.49	23.95	25.87
Natasha Kaiser-Brown	12.41	11.37	12.69	13.70	23.78	26.39
Sandie Richards	12.23	11.54	12.74	13.93	23.77	26.67
Tatyana Alekseyeva	12.07	11.41	12.62	14.42	23.48	24.07
Ximena Restrepo	12.18	11.53	12.53	14.67	23.71	27.20
Sandra Myers	12.09	11.54	12.82	14.77	23.63	27.59
Juliet Campbell	12.43	11.84	12.57	14.56	24.27	27.13
Norfalia Carabali	12.79	12.06	13.00	14.07	24.85	27.07
Cathy Freeman	12.26	11.44	12.20	13.64	23.70	25.84
Sandie Richards	12.06	11.64	12.32	13.60	23.70	25.92
Jearl Miles-Clark	12.23	11.52	12.32	13.68	23.76	26.00
Grit Breuer	11.92	11.60	12.60	13.80	23.52	26.40
Falilat Ogunkoya	12.30	11.40	12.28	14.16	23.70	26.44
Helena Fuchsova	12.18	11.48	12.82	14.12	23.66	26.84
Pauline Davis	12.30	11.88	12.61	13.76	24.18	26.37
Tatyana Alekseyeva	12.24	11.24	12.80	14.92	23.48	27.72
Cathy Freeman	12.19	11.60	12.18	13.70	23.78	25.88
Anja Rücker	12.41	11.62	12.18	13.53	24.03	25.71
Lorraine Graham	12.11	11.48	12.53	13.80	23.59	26.33
Falilat Ogunkoya	12.14	11.52	12.29	14.08	23.66	26.37
Katharine Merry	12.24	11.67	12.46	14.15	23.91	26.61
Nazarova Natalya	12.29	11.80	12.82	13.70	24.09	26.52
Grit Breuer	12.39	11.69	12.43	14.16	24.08	26.59
Olga Kotlyarova	12.51	11.75	12.59	13.87	24.26	26.46
Sanya Richards	12.81	11.69	12.12	13.38	23.50	25.50
Shericka Williams	12.07	11.69	12.24	13.32	23.76	25.56
Antonina Krivoshapka	12.13	11.46	12.31	13.81	23.59	26.12
Novlene Williams-Mills	12.36	11.64	12.18	13.85	24.00	25.77
Christine Ohuruogu	12.56	11.76	12.44	13.45	24.32	25.89
Debbie Dunn	12.19	11.75	12.55	13.86	23.94	26.41
Anastasiya Kapachinskaya	12.54	11.85	12.53	13.61	24.39	26.14
Amantle Montsho	12.38	12.09	12.58	13.60	24.47	26.18

Regression analyses results of four segments of 400m event Table 2

400 m N=32	R= .99; R2= .99; Adjusted R2= .99; F(4.27)=588.67; p<0.00; SEE: .07					
	b*	Std.Err. of b*	b	Std.Err. of b	t(27)	p-value
Intercept			1.84	1.15	1.60	0.12
0-100	0.30	0.02	0.96	0.08	12.70	0.00
100-200	0.26	0.03	0.87	0.08	10.46	0.00
200-300	0.37	0.03	1.02	0.08	13.59	0.00
300-400	0.64	0.03	0.99	0.04	23.52	0.00

Coefficient of multiple correlation(R), coefficient of multiple determination (R^2), F-value (F), standard error of the estimate (SEE), dependent variable (400m); standardized regression coefficients (b), standard error of standardized regression coefficients (Std. Err.of b*); non-standardized regression coefficients (b); standard error of non-standardized regression coefficients (Std. Err.of b); t-value (t); level of significance (p)*

Results in Table 2, show that analyzed 100m segments' time parameters of running dynamics can explain 99% of total variance of 400m running results. Multiple correlation coefficient is R=0.99 which indicates level of correlation between group of predictor variables and criterion (400m final result) which showed to be statistically significant at p level of 0.00. Determination coefficient (R2=0.99) is also indicative of high predictive value of individual 400m race segments (0-100m; 100-200m; 200-300m; 300-400m) on final 400m race result. Observation of partial coefficients show that the greatest predictive value has running time from 300m to 400m (b*=0.64), followed by running time from 200m to 300m (b*=0.37), running time from start to 100m (b*=0.30) and finally, running time from 100m to 200m (b*=0.26). The analysis show that 400m race segments are statistically significant predictors; however, the segment related to final part of 400m race is the variable where the variance is found and as such is the most significant predictor of 400m event final result, which is logical. In the first segment of 400m event (between 50^{th} and 250^{th}m) runners achieve maximum running speed which is attained mostly for 150-200m, depending on runner's quality (Jovović, 2010). Maximal running speed depends on sprinter's motor abilities, movement frequency, explosive strength and speed endurance, as well as on many different factors related to morphological and physiological characteristics of a sprinter (Čoh et al., 2009). Although motor abilities such as speed, strength and speed endurance all influence final 400m race result, runners who have highly developed speed endurance abilities, and who manage to resist tiredness and pain in last segment of the race despite depletion of energy stores and decreased efficiency of nervous system, have the greatest chance to achieve the best result at the end of 400m race.

Regression analysis results in two segments of 400m sprint event Table 3

400 m N=32	R= .99; R2= .99; Adjusted R2= .99; F(2.29)=1253.9; p<0.00; SEE: .07					
	b*	Std.Err. of b*	b	Std.Err. of b	t(27)	p-value
Intercept			1.68	1.10	1.52	0.14
0-200	0.48	0.02	0.93	0.04	24.35	0.00
200-400	0.89	0.02	1.00	0.02	44.58	0.00

Coefficient of multiple correlation(R), coefficient of multiple determination (R^2), F-value (F), standard error of the estimate (SEE), dependent variable (400m); standardized regression coefficients (b), standard error of standardized regression coefficients (Std. Err.of b*); non-standardized regression coefficients (b); standard error of non-standardized regression coefficients (Std. Err.of b); t-value (t); level of significance (p)*

Table 3 shows regression coefficients of relationship between group of predictor variables (running time from start to 200m and from 200m to 400m) and criterion variable 400m final result. Multiple correlation coefficient is R=0.99 and shows correlation level between group of predictor variables and criterion which proved to be statistical significant at p level of 0.00. Determination coefficient (R2=0.99) is indicative of significant amount of shared variance, that is, of very high predictive value of variables related to running time from start to 200m (b*=0.48) and running time from 200m to 400m (b*=0.89) on final 400m race result. Running time from last 200m has higher predictive value on the result compared to running time of first 200m of 400m race. The reason for this can be found in energetic stores depletion mechanisms. Energy stores are greatly influenced by anaerobic energy concentration (ATP, CP, glucose), blood lactates accumulation, running technique deterioration due to tiredness and/or lack of speed endurance and motivation. 400m event is controlled sprint and as such, it demands patience, assertiveness and aggression from runners. In order for runners to be able to successfully run this distance, they need to learn to experience pain and to resist tiredness which is the most pronounced in last segments of the race.

6. Conclusion

This research study was carried out on deliberate and representative sample of female 400m runners who managed to participate in finals of World Championships in Athletics in Stuttgart (1993), Athens (1997), Sevilla (1999), and Berlin (2009). Entity sample was comprised of 32 results from 26 female sprinters (average age: 27.03±3.33 years; average height: 172.73±4.16 cm; average weight: 61.59±4.25 kg) and for whom official results of time parameters of running dynamics in 400m event were available. Data used in this research study were extracted from official results' list and published results on internet web page of IAAF. Variables' sample for this research study consisted of 7 variables: 4 predictor variables related to split times at every 100m, 2 predictor variables related to first and second 200m of 400m event and criterion variable – result, related to final 400m race time.

Multiple regression analysis showed very high influence of predictive variables on final result of 400m race, with 99% of shared variance at p level of 0.00. When it comes to individual variables related to every 100m segments of the race, the variable found to best predict the final result was the one relating to last 100m segment of 400m race (b*=0.64). Similarly, analysis of 200m segments variables revealed that last 200m had better predictive value (b*=0.89) compared to the first 200m. Since multiple regression analysis showed importance of all predictive variables for final result, this practically means that runners have to build on result from the start until the finish line. 400m runners' efficacy and quality is determined by equal strength distribution along entire distance, which brings importance on speed endurance and running economy (Babić, 2010). It is obvious that "sprinter type" of runners will have advantage in an early phase of the race; however, if they are not well trained this advantage will disappear by the end of the race. On another hand, runners' type dominated by speed endurance will have an advantage in the last 100m of 400m race (Hart, 2000). When it comes to training process for 400m event, it is easier to develop speed endurance in runners who are speed-based than it is to develop speed in runners who are characterized by speed endurance ability. Since there is no runner capable of running entire 400m distance with maximal speed, the capability of distributing speed and energy in the most effective way relating to overall distance is the primary mode of being successful in 400m event. Conclusively, this requires good judgment of race rhythm and effort distribution along entire 400m distance (Gambetta, 1978).

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