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Women's 50km racewalking tactic using pace strategy analysis at World Championships

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Abstract

Background and Study Aim: We aim to design a walking tactic depending on pace strategy analysis for women's 50km racewalking at two IAAF championships: World Racewalking Team Championships Taicang2018 and World Athletics Championships Doha2019.

Material and Methods: We collected data from the records of the women's 50km racewalking results from both mentioned championships in which the times of 10 stages of 5km each. The research sample included 30 racewalkers (top 15 from each championship) aged 21 to 41.

Results: Results indicate that elite racewalkers followed a variable pace strategy. As they started a 50km racewalking with a slow and appropriate speed. Then there was a gradual increase in the next stages until reaching the speed plateau (25km). After that, the speed was changed between increasing and decreasing until the end of the race. The results also indicate that there is a strong positive correlation between the performance time of all the stages in both championships. In addition, it is indicated that there are statistically significant differences using the T-test between all stages between both championships, except for the stage (10th 5km). So last 5km have no major impact on changes for the final classification.

Conclusions: We divided the race into seven successive tactical phases depending on the speed and the effort rate during the race stages. These phases are slow start, primary acceleration and speed regulation, the maximum speed, transitional, final acceleration, deceleration, and finish. Our analysis can extend theoretical knowledge, so coaches and racewalkers can make use of it in designing the training programs.

Keywords: 50km, racewalkers, endurance, pace strategy, performance, tactic phases.

Introduction

Racewalking is one of the long-distance races within athletics [1]. It differs from running in that one foot must tend to be always in contact with the ground [2]. At the World Athletics Program and the Olympic Games, (men and women) compete in two racewalking distances (20km and 50km). 50km Racewalking is the longest athletics event held as part of the Olympic Games and World Athletics Championships [3]. It became part of the Olympic schedule in 1932 for men [4] and IAAF World Championships scheduled in 2017 for women [5]. This event lasts nearly 4 hours of competition with keeping a gait rhythm that follows IAAF rules 230,1 [3, 6]. And the racewalker attempts to complete a known distance in the shortest amount of time available [7]. Pacing in racewalking is a basic requirement of endurance performance success [8, 9]. Endurance performance in marathon races also has been associated with pacing among physiological and psychological factors [7, 10].

Pace strategy refers to the mechanism by which athletes manage their rate of energy consumption to complete a challenge in the shortest time [11]. This strategy is a basic prerequisite of competitive endurance, a critical factor for performance [7, 9]. Championship racing features much more variable pacing that reflects tactical decision-making. Where the primary aim of elite athletes is to win regardless of finishing time [12]. The majority of long-distance races are held at a pace lower than the critical speed, which is the speed above which finite, primarily non-oxidative exercise is conducted [13, 14]. The aim of an effective pacing strategy is to deplete all possible energy reserves (whether by anaerobic or aerobic metabolism) by the end of the race, but not so early so disastrous deceleration doesn't occur [13].

Even so, it is currently unclear if racewalkers use pre-programmed tactics or "unconsciously" perform assigned tactics while racewalking. And since the analysis of digital achievement levels of elite racewalkers is an indicator and auxiliary guide for both coaches and racewalkers. As it helps them to distribute effort during the race stages and know the tactic of performance for the race stages. So that, the coach during the training processes can take care of them and train them according to scientific results. To this day, sport literature has not been interested in tactical analysis in women's 50km racewalking. And therefore, we will study the women's 50km racewalking to find out the relationship between the race stages in two championships. These championships are IAAF World Racewalking Team Championships Taicang 2018 and IAAF World Athletics Championships Doha 2019. In this paper, we analyze the performance time during races stages that affect and contribute to the level of digital

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achievement of women world champions. We identify the relationship between stages using statistical parameters. Therefore, we could design a walking tactic depending on pace strategy analysis at mentioned championships to help coaches and racewalkers in designing training programs.

The purpose of our research can be summarized from the IAAF World Racewalking Team Championships Taicang 2018 (**WRTC2018**) and IAAF World Athletics Championships Doha 2019 (**WAC2019**), through:

1. Analysis of the performance times of the 50km walking stages for the elite racewalkers in terms of the pacing strategy.
2. Determine the correlations between the times of the women's 50km racewalking stages and the final time of 50km.
3. Identify the differences between the times of the women's 50km racewalking stages and the final time of 50km.
4. Designing a walking tactic by dividing the women's 50km racewalking into phases according to pace strategy and effort rate

The remainder of the paper is divided as follows: Section 2 introduces the material and methods. Experimental results are illustrated in Section 3. Section 4 summarizes the discussion of these results. Finally, Section 5 discusses the conclusions of the paper.

Material and Methods

Participants

The research sample in this paper includes 30 racewalkers, where the top 15 racewalkers were selected from each of two championships (WRTC2018 and WAC2019) [15, 16] aged 21 to 41, with a mean of 28.4.

The current study is a focused review with a practical application of the theoretical foundation in the race.

Independent variables: 30 high-level women athletes in the 50 km racewalking in both championships, they are divided into two groups: the first group was those top 15 in WRTC2018, and the second group is top 15 in WAC2019.

Dependent variables: The performance of top-level women athletes in the race of 50 km. The individual times of the athletes in the 10 stages of the race, as well as their pace strategy and the effort rate.

Research Design

Initially, we collected data from the records of the women's 50km racewalking results in WRTC2018 and WAC2019. These data were obtained from IAAF's competition archive [15, 16]. The certified distance of the racewalking (50km) divided into 10 stages of 5km each was recorded, as the overall race times and 5km split times were obtained for racewalkers in both championships from IAAF's archive. The same thing happened with the times (average, final) corresponding to the individual stages (5 km) of the race. Based on the data of the individual race distances and the respective times of the athletes, the pace strategies were found that describe the athletes' tactics in this race.

Statistical analysis

The statistical analysis in both championships in this paper included:

1. Descriptive statistics: mean (M), standard deviation (SD), coefficient of variation (V), Maximum value (MAX), and Minimum value (MIN).
2. Pace strategy analysis and effort rate
$$\frac{Average\ speed\ of\ each\ stage}{Average\ speed\ of\ 50km} * 100$$
3. Rate of Change (ROC) in speed
$$\frac{Average\ speed\ (WAC2019) - Average\ speed\ (WRTC2018)}{Average\ speed\ (WRTC2018)} * 100$$
4. Relations between performance times for stages and final stage:
   - Correlation coefficients (r),
   - Analysis of variance (Enova: Single Factor), and
   - T-Test.

Results

The following results expand the theoretical knowledge of women's pace strategy in 50km of racewalking. The time for the 15 racewalkers in the 50km racewalking at in **WRTC2018** ranged from (4:04:36) to (4:28:49) hours = (14676) to (16129) sec., and the time for the 15 racewalkers in the 50km racewalking at in **WAC2019** ranged from (4:23:26) to (4:58:44) hours = (15806) to (17924) sec. Nine racewalkers are the same in both Championships, which means that these athletes had a high level of training experience and endurance. The ranking positions, racewalkers' ages, and performance time for 15 racewalkers in both Championships are shown in Table 1 and Figure $1_{a,b}$.

Table 2 illustrates the mean, minimum, maximum, standard deviation, variation coefficient for 30 racewalkers in both championships (15 in each). It is indicated that the coefficient of variation (CV) ranged between (0.792: 8.127) %, which is less than 30%, which indicates the homogeneity of the research sample.

Figure 2 shows the average speed that ranged between (3.295: 2.95) m/s in both championships and the best average speed was in the stage (5th 5km) which was 3.295 m/s at **WRTC2018.** The lowest average speed was in the stage (9th 5km) which was 2.95 m/s at **WAC2019**.

Figure 3 shows the average effort rating at each stage of 50km racewalking concerning the average effort of the final 50km. This rate is increased during the (2nd to 8th) 5km and decreased during the (1st - 9th - 10th) 5km in **WRTC2018**. In **WAC2019**, the effort rate was increased with (3rd to 7th and 10th) 5km and decreased with (1st -2nd - 8th - 9th) 5km.

Table 3 shows the performance time average (sec), average speed (m/s), and effort rate (%) between the stages and final 50km in both championships. In **WRTC2018**, the racewalkers started (1st 5km) with an average speed of 3.234 m/s. Then the average speed gradually increased until it reached its highest value at (5th 5km), with an average of 3.295 m/s. Then the average speed gradually decreased until the end of the race. In **WAC2019**, the racewalkers started (1st 5km) with an average speed of 2.969 m/s. The average speed gradually increased until it reached its highest value at the (5th 5km) with an average of 3.025 m/s. After that, the average speed decreased

Table 1. Ranking positions, Ages of racewalkers (year), and Performance time (sec) of 50km. N=30

Ranking positions	WRTC2018 (n=15)			WAC2019 (n=15)		
	racewalkers	Age (year)	The time of 50km (sec)	racewalkers	Age (year)	The time of 50km (sec)
1	Rui Liang	23	14676	Rui Liang	25	15806
2	Hang Yin	21	14949	Maocuo Li	26	16000
3	Claire Tallent	36	14973	Eleonora Giorgi	30	16153
4	Paola Pérez	28	15176	Olena Sobchuk	23	16418
5	Faying Ma	24	15208	Faying Ma	26	16496
6	Johana Ordóñez	30	15268	Khrystyna Yudkina	34	16560
7	Maocuo Li	25	15287	Magaly Bonilla	27	16623
8	Júlia Takács	28	15397	Júlia Takács	30	16700
9	Nastassia Yatsevich	33	15480	Paola Pérez	29	16734
10	Nadzeya Darazhuk	28	15511	Maria Juárez	26	16768
11	Magaly BONILLA	26	15544	Masumi Fuchise	33	16862
12	Khrystina Yudkina	33	15735	Nastassia Yatsevich	34	17041
13	Vasylyna Vitovshchyk	28	15848	Nadzeya Darazhuk	29	17246
14	Mayra Herrera	29	16110	Angeliki Makri	41	17649
15	Alina Tsvilii	23	16129	Mara Ribeiro	24	17924
Mean (M)		**27.67**	**15419.40**	Mean	29.13	16732
Standard Deviation (SD)		**4.19**	**414.85**	Standard Deviation	**4.78**	**571.02**
coefficient of variation (C.V)		**15.13**	**2.69**	coefficient of variation	**16.40**	**3.41**
Max		**36**	**16129**	Max	**41**	**17924**
Min		**21**	**14676**	Min	**23**	**15806**

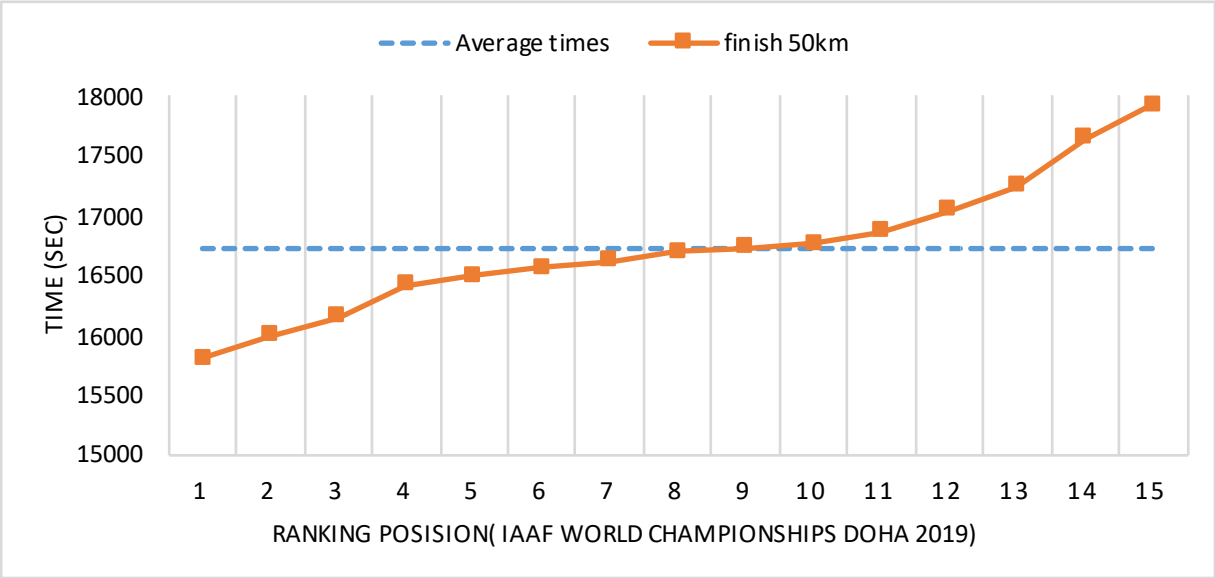

Figure 1$_a$**.** The performance time of women's 50km racewalking in relation to their classification position for WAC2019

gradually to (9th 5km) and increased significantly in the last stage of the race at the (10th 5km).

Table 4 and Figure 4 show the rate of change in speed between both championships for each stage. It is noticed that there are differences in rates of change in speeds at all stages in favor of **WRTC2018**. The largest value of change rate in speed is 30% in the (2nd 5km), and the lowest value is 8% in the (10th 5km). The change rate in the speed of the final 50km is 26%.

Table 5 and Figure 5 show correlation coefficients (r) between the performance times averages of the race stages and the final 50km in **WAC2019**. It is noticed that so there was a direct correlation between all the stages of the race and each other. There is a strong positive correlation between all the stages and the final 50km. The largest correlation coefficient for the performance

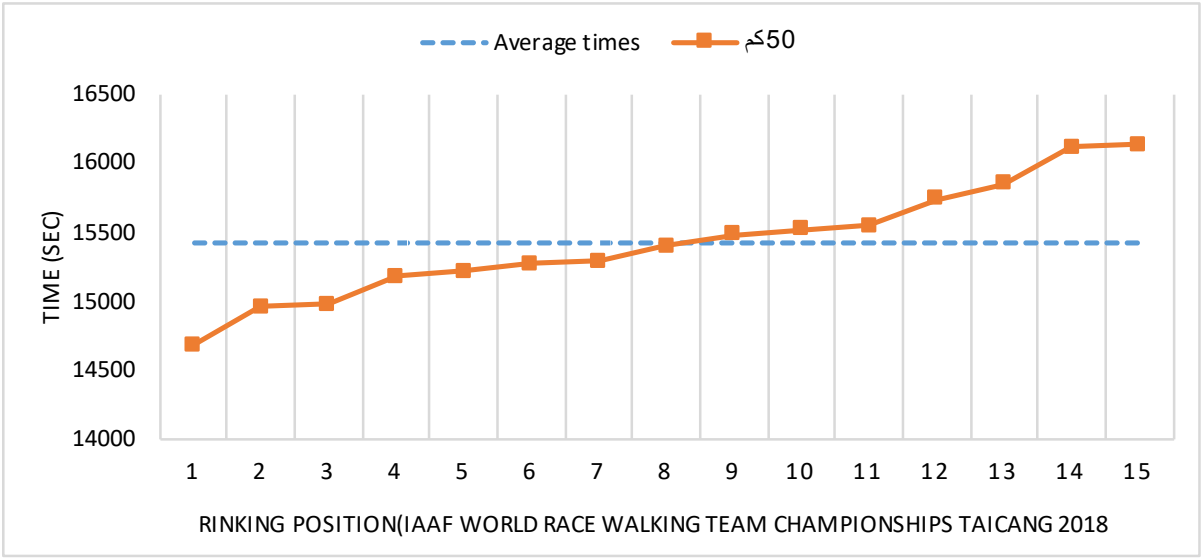

Figure 1$_b$. The performance time of women's 50km racewalking in relation to their classification position for WRTC2018

Table 2. Mean (M), Standard Deviation (SD), Coefficient of Variation (C.V), Maximum (Max), and Minimum (Min) of performance time for race stages in both Championships.

Race stages	WAC2019					WRTC2018				
	Mean(M) of performance time (sec)	Standard Deviation (SD)	coefficient of variation (C.V)	Max	Min	Mean(M) of performance time (Sec)	Standard Deviation (SD)	coefficient of variation (C.V)	Max	Min
1st 5km	1546.1	58.982	3.815	1648	1478	1684.1	13.344	0.792	1705	1666
2nd 5km	1527.3	52.075	3.410	1621	1464	1680.6	22.878	1.361	1737	1651
3rd 5km	1523.7	45.600	2.993	1606	1471	1671.4	34.096	2.040	1713	1614
4th 5km	1519.5	35.510	2.337	1577	1475	1662.8	34.262	2.061	1707	1598
5th 5km	1517.3	34.159	2.251	1566	1479	1652.9	48.295	2.922	1714	1573
6th 5km	1532.1	31.827	2.077	1599	1480	1657.6	59.448	3.586	1753	1550
7th 5km	1526.5	46.223	3.028	1631	1475	1671.7	79.725	4.769	1854	1521
8th 5km	1540.1	54.872	3.563	1680	1461	1690.2	99.378	5.880	1907	1540
9th 5km	1562.8	63.789	4.082	1715	1416	1695.0	118.097	6.967	1974	1548
10th 5km	1624.0	131.979	8.127	1933	1426	1665.7	110.982	6.663	1885	1543
Final 50km	15419.4	**414.852**	**2.690**	**16129**	**14676**	**16732.0**	**571.024**	**3.413**	**17924**	**15806**

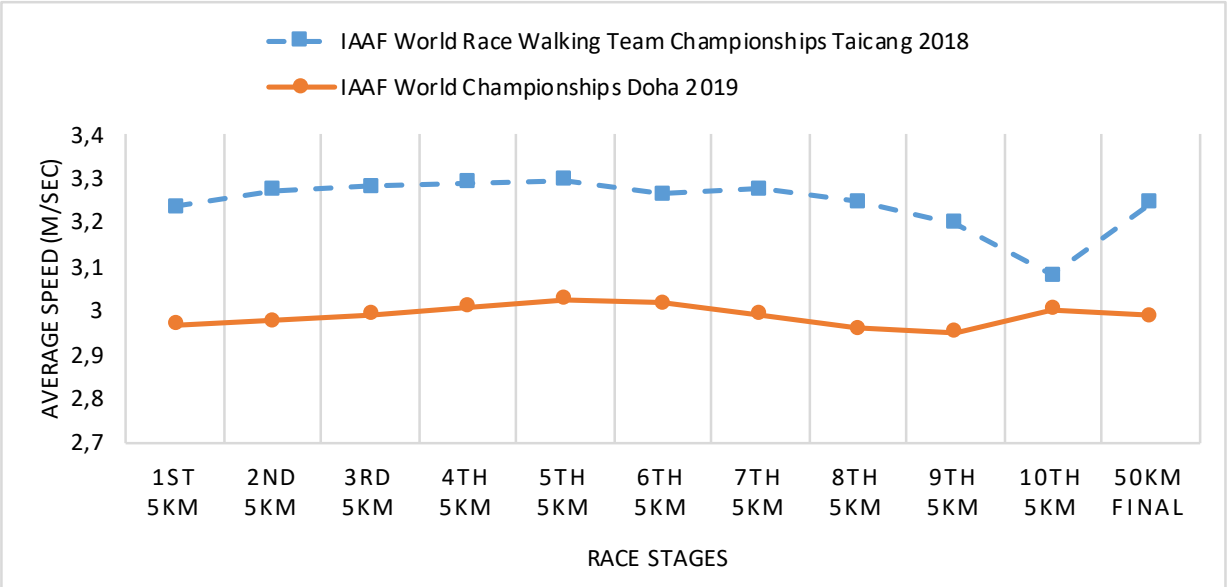

Figure 2. Average Speed (m/sec) of the stages of women's 50km racewalking

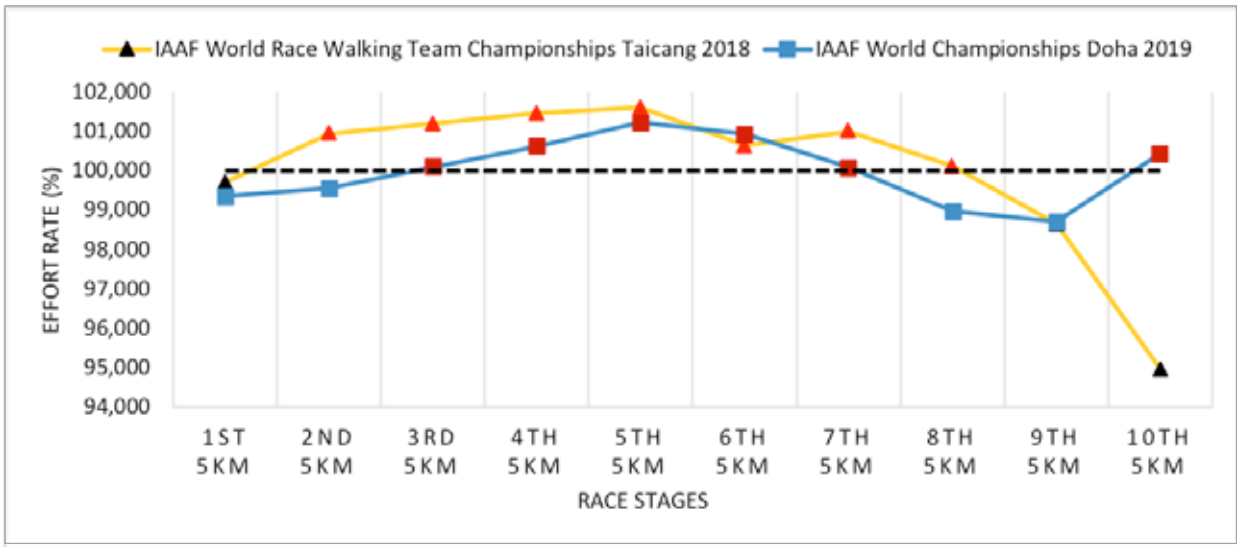

Figure 3. Effort rate (%) of the stages of women's 50km racewalking

Table 3. Average Performance Time (sec), Average Speed (m/sec), and Effort Rate between the stages and final 50km (%) in both Championships.

Race stages	WAC2019				WRTC2018			
	Mean(M) of performance time (sec)	Average Speed (m/sec)	Change in velocity (m/s)	Effort rate (%)	Mean(M) of performance time (Sec)	Average Speed (M/Sec)	Change in velocity (m/s)	Effort rate (%)
1st 5km	1546.1	3.234	0.009	99.729	1684.1	2.969	0.019	99.355
2nd 5km	1527.3	3.274	-0.031	100.961	1680.6	2.975	0.013	99.560
3rd 5km	1523.7	3.282	-0.039	101.199	1671.4	2.992	-0.003	100.108
4th 5km	1519.5	3.290	-0.048	101.475	1662.8	3.007	-0.019	100.625
5th 5km	1517.3	3.295	-0.053	101.622	1652.9	3.025	-0.037	101.230
6th 5km	1532.1	3.263	-0.021	100.640	1657.6	3.016	-0.028	100.941
7th 5km	1526.5	3.276	-0.033	101.014	1671.7	2.991	-0.003	100.088
8th 5km	1540.1	3.247	-0.004	100.122	1690.2	2.958	0.030	98.994
9th 5km	1562.8	3.199	0.043	98.665	1695.0	2.950	0.038	98.714
10th 5km	1624.0	3.079	0.164	94.947	1665.7	3.002	-0.013	100.448
Final 50km	15419.4	3.243			16732.0	2.988		

Table 4. Rate of change in speed (%) between both Championships for each stage.

Race stages	WRTC2018		WAC2019		rate of change in speed (%)
	Mean(M) of performance time (sec)	Speed (m/sec)	Mean(M) of performance time (Sec)	Speed (M/ Sec)	
1st 5km	1546.1	3.234	1684.1	2.969	27%
2nd 5km	1527.3	3.274	1680.6	2.975	30%
3rd 5km	1523.7	3.282	1671.4	2.992	29%
4th 5km	1519.5	3.290	1662.8	3.007	28%
5th 5km	1517.3	3.295	1652.9	3.025	27%
6th 5km	1532.1	3.263	1657.6	3.016	25%
7th 5km	1526.5	3.276	1671.7	2.991	29%
8th 5km	1540.1	3.247	1690.2	2.958	29%
9th 5km	1562.8	3.199	1695.0	2.950	25%
10th 5km	1624.0	3.079	1665.7	3.002	8%
Final 50km	15419.4	3.243	16732.0	2.988	26%

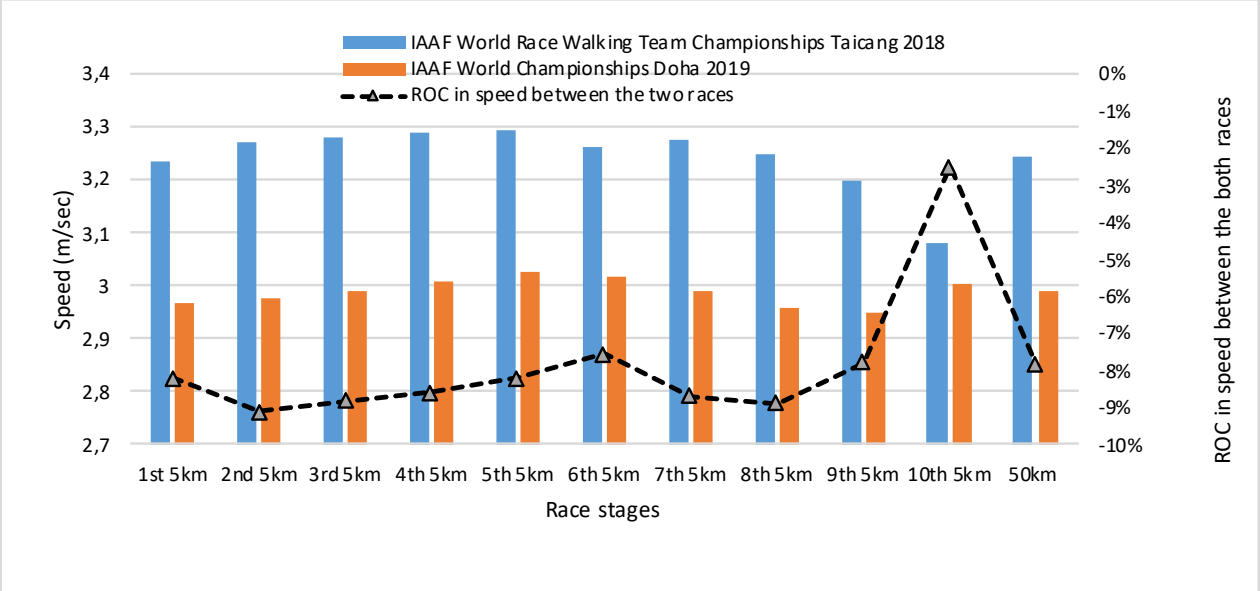

Figure 4. Rate of change in speed (%) between both Championships for each stage.

Table 5. Correlation coefficients (r) between the performance times averages of stages and with final 50km in **WAC2019.**

Race Stages	Final 50km	1st 5km	2nd 5km	3rd 5km	4th 5km	5th 5km	6th 5km	7th 5km	8th 5km	9th 5km	10th 5km
Final 50km	X										
1st 5km	.895**	X									
2nd 5km	.910**	.790**	X								
3rd 5km	.817**	.713**	.831**	X							
4th 5km	.860**	.829**	.800**	.958**	X						
5th 5km	.901**	.890**	.860**	.880**	.938**	X					
6th 5km	.909**	.769**	.881**	.859**	.881**	.860**	X				
7th 5km	.939**	.767**	.878**	.796**	.829**	.829**	.945**	X			
8th 5km	.979**	.829**	.902**	.779**	.793**	.849**	.868**	.918**	X		
9th 5km	.936**	.817**	.791**	.600*	.651**	.744**	.746**	.834**	.955**	X	
10th 5km	.907**	.884**	.752**	.594*	.681**	.747**	.706**	.764**	.863**	.927**	X

*Correlation is significant at the 0.01 level (2-tailed).***

*Correlation is significant at the 0.05 level (2-tailed).**

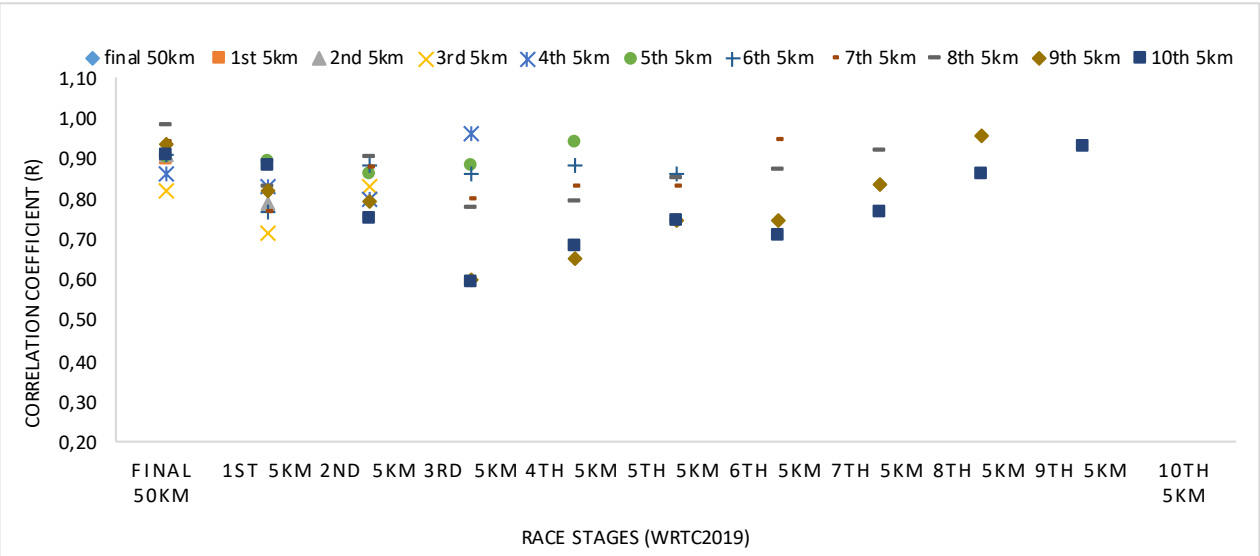

Figure 5. Correlation coefficients (r) between the performance times averages of the women's 50km racewalking stages in **WRTC2019.**

times of stages is (8th 5km with r= 0.979), and the lowest correlation coefficient is (3rd 5km with r= 0.817).

Table 6 and Figure 6 show correlation coefficients (r) between the performance times averages of the stages and the final 50km in **WRTC2018**. It is noticed that there was a direct correlation between all the stages of the race and each other. There is a strong positive correlation between all the stages and the final 50km. The largest correlation coefficient for the performance times of stages is (5th 5km with r= 0.918), and the lowest correlation coefficient is (10th 5km with r= 0.594).

Table 7 and Figure 7 show correlation coefficients (r) between the performance times averages of the stages and the final 50km in both championships. It is noticed that there is a strong positive correlation between the final 50 km in both championships, (r=0.988). Also, there is a strong positive correlation between the performance times of all stages in both championships. Where there is a high correlation coefficient between the successive stages, at the distances between 15 and 20 km (r=0.999 in **WTC2018**, r=0.994 in **WAC2019**) and between 20 and 25 km (r=0.994 in **WTC2018**, r=0.995 in **WAC2019**). While the correlation coefficient of performance times between 5km to 10km (r=0.978 in **WTC2018**, r=0.913 in **WAC2019**) is the lowest correlation coefficient between the successive stages.

Table 6. Correlation coefficients (r) between the performance times averages of stages and with final 50km in **WRTC2018.**

Race Stages	Final 50km	1st 5km	2nd 5km	3rd 5km	4th 5km	5th 5km	6th 5km	7th 5km	8th 5km	9th 5km	10th 5km
Final 50km	X										
1st 5km	.776**	X									
2nd 5km	.815**	.903**	X								
3rd 5km	.758**	.914**	.760**	X							
4th 5km	.860**	.934**	.916**	.937**	X						
5th 5km	.918**	.842**	.871**	.793**	.916**	X					
6th 5km	.715**	.435	.500	.444	.574*	.778**	X				
7th 5km	.872**	.594*	.740**	.587*	.757**	.882**	.829**	X			
8th 5km	.743**	.375	.507	.440	.568*	.720**	.610*	.858**	X		
9th 5km	.751**	.314	.441	.315	.443	.623*	.518*	.732**	.889**	X	
10th 5km	.594*	.231	.227	.225	.241	.288	.312	.290	.183	.423	X

*Correlation is significant at the 0.01 level (2-tailed).***

*Correlation is significant at the 0.05 level (2-tailed).**

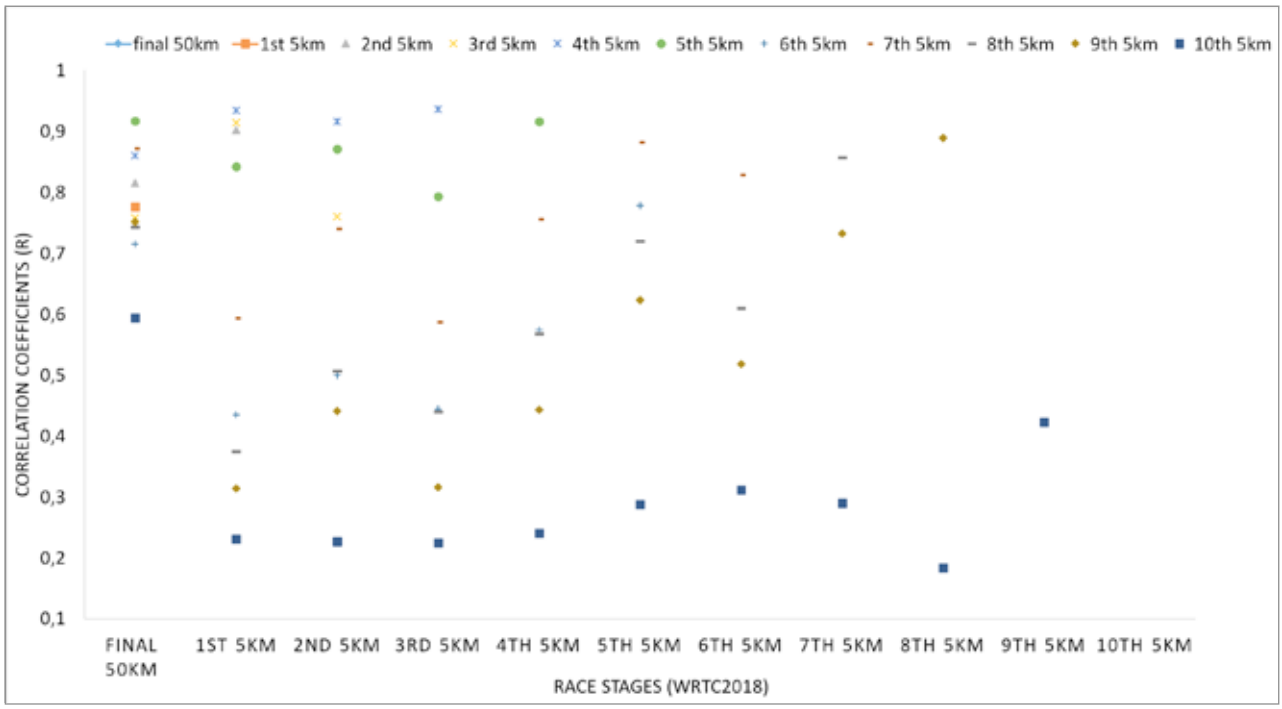

Figure 6. Correlation coefficients (r) between the performance times averages of the women's 50km racewalking stages in **WRTC2018.**

Table 7. Correlation coefficients (r) between the performance times averages of the race stages in both Championships.

Race Stages		Taicang										Doha								
		5km	10km	15km	20km	25km	30km	35km	40km	45km	50km	5km	10km	15km	20km	25km	30km	35km	40km	45km
Taicang	10km	.978**	X																	
	15km	.988**	.988**	X																
	20km	.982**	.985**	.999**	X															
	25km	.974**	.982**	.995**	.997**	X														
	30km	.954**	.967**	.979**	.984**	.994**	X													
	35km	.922**	.948**	.957**	.965**	.980**	.994**	X												
	40km	.876**	.912**	.922**	.933**	.954**	.974**	.991**	X											
	45km	.826**	.870**	.877**	.889**	.915**	.939**	.965**	.990**	X										
	50km	.776**	.814**	.822**	.832**	.858**	.886**	.911**	.932**	.954**	X									
Doha	5km	.804**	.852**	.833**	.839**	.860**	.871**	.877**	.885**	.892**	.913**	X								
	10km	.669**	.713**	.714**	.725**	.759**	.789**	.819**	.854**	.889**	.956**	.913**	X							
	15km	.670**	.693**	.714**	.724**	.746**	.762**	.779**	.800**	.825**	.927**	.851**	.957**	X						
	20km	.692**	.714**	.738**	.748**	.766**	.777**	.788**	.802**	.820**	.920**	.853**	.934**	.994**	X					
	25km	.693**	.721**	.742**	.754**	.772**	.784**	.798**	.816**	.837**	.927**	.875**	.938**	.987**	.995**	X				
	30km	.683**	.711**	.735**	.749**	.771**	.788**	.807**	.829**	.851**	.937**	.861**	.941**	.984**	.990**	.992**	X			
	35km	.671**	.700**	.726**	.740**	.764**	.784**	.809**	.833**	.859**	.947**	.850**	.942**	.972**	.975**	.975**	.993**	X		
	40km	.691**	.725**	.744**	.757**	.780**	.802**	.829**	.851**	.876**	.964**	.859**	.953**	.967**	.963**	.964**	.981**	.994**	X	
	45km	.718**	.756**	.766**	.777**	.801**	.825**	.854**	.873**	.895**	.977**	.873**	.952**	.941**	.931**	.935**	.953**	.972**	.991**	X
	50km	.755**	.793**	.800**	.810**	.834**	.860**	.887**	.904**	.922**	.988**	.895**	.952**	.925**	.914**	.920**	.935**	.955**	.978**	.995**

Correlation is significant at the 0.01 level (2-tailed).**

Table 8 shows the calculated F value which is less than the critical F value at α = 0.05. This means that there are no statistically significant differences between the performance times of the race stages in **WAC2019**.

Table 9 shows the calculated F value which is greater than the critical F value at α = 0.05. This means that there are statistically significant differences between the performance times of the race stages in **WRTC2018**.

Table 10 shows the significant differences between the performance times averages of each stage. It is noticed

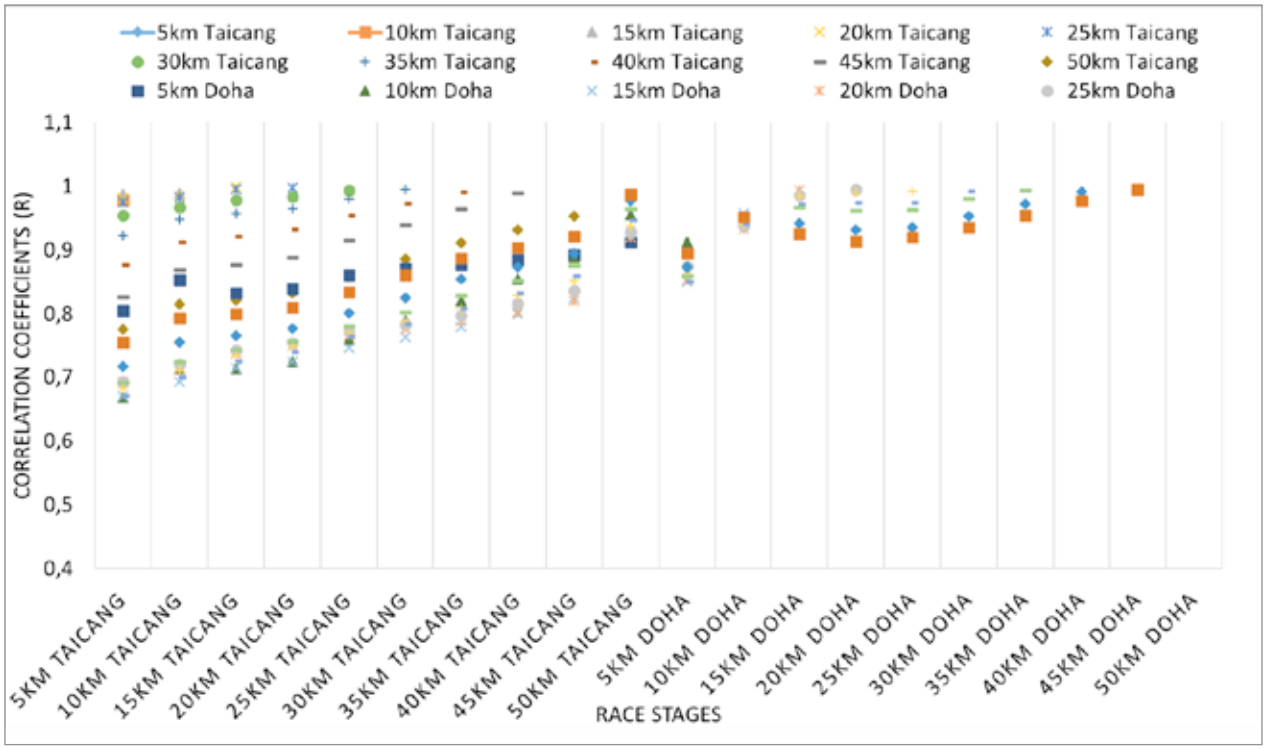

Figure 7. Correlation coefficients (r) between the performance times averages of the race stages in both Championships.

Table 8. Analysis of variance (ANOVA: Single Factor) between performance time averages of the race stages in **WAC2019.**

	Source of Variation	SS	df	MS	F	P-value	F crit
IAAF World Championships Doha 2019	Between Groups	26447.87	9	2938.652	0.571716	0.8185	1.947348
	Within Groups	719608.1	140	5140.058			
	Total	746056	149				

$F=0.571716 < 1.947348 = F_{0.05(9,140)}$

Table 9. Analysis of variance (ANOVA: Single Factor) between performance time averages of the race stages in **WRTC2018**

	Source of Variation	SS	df	MS	F	P-value	F crit
IAAF World Racewalking Team Championships Taicang 2018	Between Groups	137736.6	9	15304.07	3.991062	0.000147	1.947348
	Within Groups	536841.9	140	3834.585			
	Total	674578.5	149				

$F=3.991062 > 1.947348 = F_{0.05(9,140)}$

that there are statistically significant differences between the performance time average of the (5th 5km) and that of (9th 5km) in favor of the (5th 5km). likewise, there are statistically significant differences between the performance time average of each stage (1st to 9th) 5km and that of (10th) 5km in favor of the stage itself (1st to 9th) 5km.

Table 11 shows the calculated T value which ranged between (5.55 – 29.216), which is greater than the critical T value at $\alpha = 0.05$). This means that there are statistically significant differences between the values of the stages between both championships. Except for the stage (10th 5km), where the calculated T value = (1,212) is less than the critical T value $T_{0.05}$=1.753.

Discussion

We can observe by analyzing the pacing strategy at 50km of racewalking. The average effort rating and average speed increased with the start of the race from the (1st 5km) to the (5th 5km). Then it began to decrease from the (6th 5km), and increased again in the (7th 5km), and decreased from the (8th 5km) to the (10th 5km) in

Table 10. The significant differences between performance times averages of each stage in **WRTC2018**.

IAAF World Racewalking Team Championships Taicang 2018	Race Stages	Mean(M) of performance time (sec)	LSD	1st 5km	2nd 5km	3rd 5km	4th 5km	5th 5km	6th 5km	7th 5km	8th 5km	9th 5km	10th 5km
	1st 5km	1546.1			18.87	22.47	26.60	28.80	14.00	19.67	6.07	-16.67	-77.87
	2nd 5km	1527.3				3.60	7.73	9.93	-4.87	0.80	-12.80	-35.53	-96.73
	3rd 5km	1523.7					4.13	6.33	-8.47	-2.80	-16.40	-39.13	-100.33
	4th 5km	1519.5						2.20	-12.60	-6.93	-20.53	-43.27	-104.47
	5th 5km	1517.3							-14.80	-9.13	-22.73	-45.47	-106.67
	6th 5km	1532.1	44.70							5.67	-7.93	-30.67	-91.87
	7th 5km	1526.5									-13.60	-36.33	-97.53
	8th 5km	1540.1										-22.73	-83.93
	9th 5km	1562.8											-61.20
	10th 5km	1624.0											

Table 11. T-test for performance time averages of each stage and final 50km between both Championships

Race Stages	WRTC2018		WAC2019		F	calculated T
	Mean(M) of performance time (sec)	Standard Deviation(SD)	Mean(M) of performance time (sec)	Standard Deviation(SD)		
1st 5km	1546.1	58.982	1684.1	13.344	12.63	10.925
2nd 5km	1527.3	52.075	1680.6	22.878	11.06	13.863
3rd 5km	1523.7	45.600	1671.4	34.096	8.64	17.108
4th 5km	1519.5	35.510	1662.8	34.262	5.80	24.700
5th 5km	1517.3	34.159	1652.9	48.295	7.66	17.684
6th 5km	1532.1	31.827	1657.6	59.448	11.95	10.503
7th 5km	1526.5	46.223	1671.7	79.725	13.19	11.015
8th 5km	1540.1	54.872	1690.2	99.378	19.40	7.737
9th 5km	1562.8	63.789	1695.0	118.097	23.82	5.550
10th 5km	1624.0	131.979	1665.7	110.982	34.43	1.212
Final 50km	15419.4	414.852	16732.0	571.024	44.93	29.216

critical $T_{0.05}$ =1.753

WRTC2018. The average speed took a strategy similar to the wave shape (M). The effort rate and average speed in **WAC2019** gradually increased with the start of the race from the (1st 5km) to the (5th 5km). Then it began to decrease from the (6th 5km) to the (9th 5km) and increased again in the (10th 5km). The average speed took a strategy similar to the letter shape (N). It is clear that the (5th 5km) stage is considered the fastest and best stage in the effort rate in both championships.

In addition, the (1st 5km) came in the eighth rank in the effort rate and average speed in both championships. This indicates that the racewalkers prefer to use a slow-start pacing strategy as mentioned in the literature. It is to reduce the rate of carbohydrate store depletion by reducing the contribution of the anaerobic glycolytic phosphorylation system [7]. Also, to limit the lactate accumulation and the amount of anaerobic energy reserve used during the beginning of the race to avoid early fatigue [17]. This procedure may become a success factor for the race.

The speed after those increases in a linear fashion from the (2nd 5km), continues to the (5th 5km). To improve the ranking by gradually increasing the effort rate and average speed in both championships. So, we can say that Cardio-respiratory endurance and special endurance play an important role in that phase. This requires successive effort from the start of the race to completing the 25km (i.e., half the race). This will enable the most efficient utilization of aerobic energy system, as well as a complete utilization of their anaerobic capacity [9].

Then a slight decrease in speed during the (6th 5km) for both championships to maintain the ranking achieved by the racewalkers. This decrease in speed is caused by fatigue and the formation of lactic acid in the muscles. As the muscle quickly gets rid of the lactic acid and returns to recovery again. After that, they increased their speeds again during the (7th 5km) in an attempt to improve the ranking. Then a gradual decline from the (8th 5km) to the end of the race (10th 5km) in **WRTC2018**. This is due to the arrival of the racewalkers to the beginning of the phase of fatigue, which would decrease the speed of walking. On the other hand, the effort rate and the average speed continued to decrease from the (7th 5km) to (9th 5km) in **WAC2019**. That is due to the beginning of the phase of fatigue. Then the last stage (10th 5km) increased in the average speed in an attempt to improve the ranking and finish the race.

We believe that a difference occurred in the speed strategy organization in the (7th 5km) and (10th 5km) stages between both championships. It is due to the racewalkers' fear that the race will not be completed due to the extreme temperatures and humidity during **WAC2019**. As the temperature was (30- 31) ° c and humidity was (70-74) % from the start of the race until the end [15]. As mentioned by researchers that playing sports in hot environments leads to physiological tension in the body. This is compared with temperate- and low-ambient temperatures [18], so this means that the pacing is affected by the climatic setting.

Comparing the average values of speed of the stages in both championships, there was a clear difference in the rate of change in speed in favor of **WRTC2018**. As the rates of change in speed ranged from 8% to 30% during the different stages of the 50km racewalking. We think that these differences are due to temperature, humidity, and location of the race.

The results of correlation coefficients indicate that there is a strong positive correlation between the performance time averages of all the stages in both championships. There was a high correlation coefficient between the successive stages, at distances between 15 and 20 km and between 20 and 25 km. This is because the 50km racewalkers must have high Cardio-respiratory endurance. While the time correlation coefficient between 5km to 10km was the lowest correlation coefficient between the successive stages. This means that the racewalkers started the race at a slow and suitable speed. That allowed them to reserve a place at the front of the race. Not to accumulate lactic acid in the muscles, thus avoiding the occurrence of early fatigue.

The results of the T-test indicated that there were statistically significant differences between the values of the stages between both championships, except for the (10th 5 km). In the (10th 5 km), the calculated T value = (1,212) was less than the critical value ($T_{0.05}$=1.753). The results of the variance analysis indicated that there are statistically significant differences between the performance time averages of stages and that of (10th 5km) in favor of all the stages in **WRTC2018**. This means that the last 10km have no major impact on changes for the final classification. So, we suggest changing the distance of this race for women in the World Championships scheduled to the 45km racewalking instead of the 50km racewalking.

From the discussion of all the previous results, we design a walking tactic by dividing the women's 50km racewalking into seven successive phases. The phases on which elite racewalkers depend for regulating the speed and the effort rate during the stages of 50km racewalking, which are as follows:

1- Slow start phase

It is the phase in which the racewalkers exert less effort as intensity ranged from (99.4: 99.7)% from the total effort rate of 50km racewalking. To limit the amount of anaerobic energy reserve during the beginning of the race to avoid early fatigue metabolite accumulation. This phase aims to start the race at a slow and suitable speed that allows the racewalkers to reserve a place at the front of the race. This stage continues for 5km.

2- Primary acceleration and speed regulation phase

It is the phase in which the racewalkers make more effort than the previous stage. This is done gradually as intensity ranged from (99.6: 101.2)% from the total effort rate of 50km racewalking. This phase aims to improve the ranking and obtain an advanced position in the race between the racewalkers. This phase is considered the most important one because it continues for 15km that is a long distance between all phases. Aerobic capacity

exercises (e.g., long-distance run and racewalking exercise, water exercise, interval exercise, country aerobics, power stepping, step exercise, funk aerobics) play an important role in that phase for developing cardio-respiratory endurance. This is an addition to the acceleration exercises.

3- Maximum speed (speed plateau) phase

At this phase, the racewalkers achieve the highest speed and exert the highest effort as intensity ranged from (101.2: 101.6) % from total effort rate. This phase results in the formation of waste to accumulate waste of energy and lactic acid in the muscles. This affects the decrease in speed in the next phase. This phase aims to compete in obtaining an advanced position in the race, this phase continues for 5km. Anaerobic capacity plays an important role in that phase and there should be a constantly monitoring of the racewalker's (VO2max) and anaerobic capacity during train.

4- Transitional phase

It is the phase in which the speed is relatively reduced. The racewalkers exert less effort than the previous stage and more effort than the total effort of the race. To get rid of accumulated lactic acid in the muscles and return to the state of recovery again. As intensity ranged from (100.6: 100.9)% from the total effort rate of 50km racewalking. So that the racewalkers can continue to perform until the end of the race. This phase aims to preserve the level reached by the racewalkers; this phase continues for 5km. Anaerobic capacity exercises play an important role in that phase. While maximizing the racewalkers aerobic capacity in order to prevent premature termination. Also, there should be constantly monitoring of the racewalker's (VO_{2max}) and anaerobic capacity during train.

5- Final acceleration phase

At this phase, the racewalkers increase the speed and exerting more effort than the effort of the previous phase (fourth phase). As intensity ranged from (100.1: 101)% from the total effort rate of 50km racewalking. This phase aims to maintain the level and improve the ranking, this stage continues for 5km. Anaerobic and aerobic capacity plays an important role in that phase.

6- Deceleration phase

It is the phase in which the speed and effort exerted gradually decreases as intensity ranged from (98.7: 100.1)% from the total effort rate. This phase is considered an indication of the onset of fatigue, and this phase continues for 10km. Special endurance and aerobic capacity play an important role in that phase.

7- The finish phase

In this phase, the racewalkers begin to finish the race and intensity ranged from (95: 100.5)% from the total effort rate of 50km racewalking. This phase aims to compete for obtaining an advanced ranking among the racewalkers and achieve a new personal performance time. It continues for 5km, Speed endurance and performance endurance play an important role in that phase.

Conclusions

In this paper, we aim to design a walking tactic depending on pace strategy analysis for women's 50km racewalking at both championships (**WRTC2018, WAC2019**). The results of major variables used in this paper can be summarized in the following points:

- The coefficient of variation (cv) ranged between (0.792: 8.127) %, which is less than 30%, which indicates the homogeneity of the research sample.
- There are correlation coefficients between the successive stages. There is a strong positive correlation between the final 50km in both championships (r=0.988) and between performance times averages of stages.
- The average speed ranged between (3.295: 2.95) m/s in both Championships. The best average speed was 3.295 m/s for (5th 5km) at **WRTC2018**. The lowest average speed was 2.95 m/s for (9th 5km) **WAC2019**.
- The average effort was increased in **WRTC2018** during the (2nd to 8th) 5km and decreased during the (1st - 9th - 10th) 5km.
- The effort rate was increased during (3rd to 7th and 10th) 5km and decreased during (1st -2nd - 8th - 9th) 5km in **WAC2019**.
- The results of the T-test indicated that there were statistically significant differences between the values of the stages, except for the (10th 5km).
- The results of the variance analysis indicated that there are statistically significant differences between the performance time of all the stages and that of the (10th 5km) in favor of all the race stages in WRTC2018.

According to our analysis, the coaches and racewalkers seem to set clear times for each stage in the race. They should follow the specific pacing strategy during the training season, regardless of the level of the championship and the level of the racewalkers. The results also indicate that the pacing strategy followed in the race by the elite racewalkers was not based on a fixed rhythm. It rather depends on a variable pace strategy from the start of the race until the end. Therefore, racewalkers must appropriately and strategically distribute aerobic and anaerobic capabilities throughout the race. Also, we note that the last 5km have no major impact on changes for the final classification. So, we suggest changing the distance of this race for women in the world championships scheduled to 45km racewalking instead of 50km racewalking.

Finally, we could divide the race tactically into seven successive phases on which elite racewalkers depend for regulating the speed and the effort rate of the race. These phases are slow start, primary acceleration, and speed regulation, maximum speed (speed plateau), a transitional phase, final acceleration, deceleration, the finish).

Future work

In this paper, we took world championships into consideration, so that our analysis could be applied for 50km racewalkers. So, we seek to design a training program in light of the supposed seven tactic stages. And check its effects on the level of achievement for women and men in 50km racewalking.

Recommendations

We recommend coaches to train racewalkers on the phases of walking tactic, each phase separately. Also, train racewalkers on performance by linking two or more phases without decreasing the rate of speed. Racewalkers should continue to produce high intensity even in conditions of extreme fatigue during training. Training programs must be aimed at creating good aerobic power and the ability to perform pacing changes in conditions of fatigue**.** Anaerobic and aerobic capacities are critical components of 50km race walking performance and should be priorities within a training program.

Conflict of interest

The authors declare that there is no conflict of interest.

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