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Analysis of Starting Pressure-Time Curve of the Top Eight Athletes of Women's 100 m in Guangzhou Asian Games

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Abstract

With the measurement of e-starting monitoring system as the main research method, this paper has studied variables of the start-pedal pressure curve of top eight athletes of women's 100 meter dash in the system in the Guangzhou Asian games, which aims to explore the factors affecting the sprint starting technology, providing theoretical reference for sprint training in our country. The research showed various parameters in the sprint starting pressure curve increase accordingly with the importance of the race; the peak power of both legs is the key to improve the starting technology; and the collaboration of both legs' pedal is the key factor affecting the peak power, which indicated improvement of collaboration of athletes' both legs' pedal is crucial to the sprint starting technology.

Keywords

Training, Starting, Monitoring System

1. Introduction

The reaction speed of sprinting includes reaction time and moving time (Zhu, 2005). Reaction time refers to the time required from receiving the stimulus to the body making a response action, that is, the time distance between the stimulus and the response, which mainly reflects the coordination and rapid response ability of the human nervous and muscular systems (Jiang, 2016). Lu and Fan (2022) believe that fast starting ability is an important special ability of athletes in track and field sprints. In the case of the same ability to run, the length of the

starting reaction directly affects the final race performance, which plays a vital role in the outcome of the race (Zhang, 2010). Today, electronic start monitoring system installed on the athletes starter which used in large games sprint race, measures the athletes starting pedal time-pressure and forms a time-pressure curve indicating the time of athletes' starting pedal pressure on the starter to the setting threshold, that infers whether the reaction time of starting is over the limitation, and which determines the athletes' situation of starting foul. This brings a new direction for starting technology research (Xie & Luo, 2013). The 16th Asian Games athletics competition adopts FP-2001 automatic electronic timer produced by China Shenzhen Phiplai Technology Co., Ltd., and its starting monitoring system works as follows: through the pressure sensor installed on the starter pedal, accurately measure the change of the athlete's rear pedal strength, monitor the starting process of the athlete throughout the process, and record the time-pressure data of the athlete's pedaling after the start, forming a time-pressure curve after the start. Based on this time, the referee determines whether the athlete's starting reaction exceeds the 100 ms limit set by the IAAF for sprinting starting reaction, and uses this as the basis for whether the athlete has committed a starting foul. However, did the variables of the pressure curve change significantly in the same athlete during different times? And among these variables, which variables are the important factors affecting the starting technique? Therefore, to better serve the sprint training, the time-pressure curve in the first round, semi-final and final of top 8 female athletes in the 100 m race of the 16th Asian Games were analyzed as well as the discussion of the differences of their starts, providing better service for sprinter training.

2. Research Subjects and Methods

2.1. Research Subjects

This paper took the top eight athletes of Women's 100 m dash at the 2010 Guangzhou Asian Games as the subjects, represented the women's 100 m Asian excellence category, whose final time ranges from 11.33 to 11.76 seconds, and the average is 11.54 seconds with an average age of 25. Two of them are from China, Japan and Vietnam respectively, one is from Thailand, and the other is from Uzbekistan.

2.2. Research Methods

2.2.1. Measurement Method

The electronic starting monitoring system obtains the starting determination time by measuring the starting pressure which indirectly infers whether the athletes exceed the limit during the starting reaction (Zhao, Wu, Han, Zhang, & Xie, 2011). According to the comparison of fitting map between Franklin M. Henry's study on the typical starting pressure curve (**Figure 1**) (Henry, 1992) and the pressure-time curve of the top eight athletes to understand the various index data of each athlete and analyze the results.

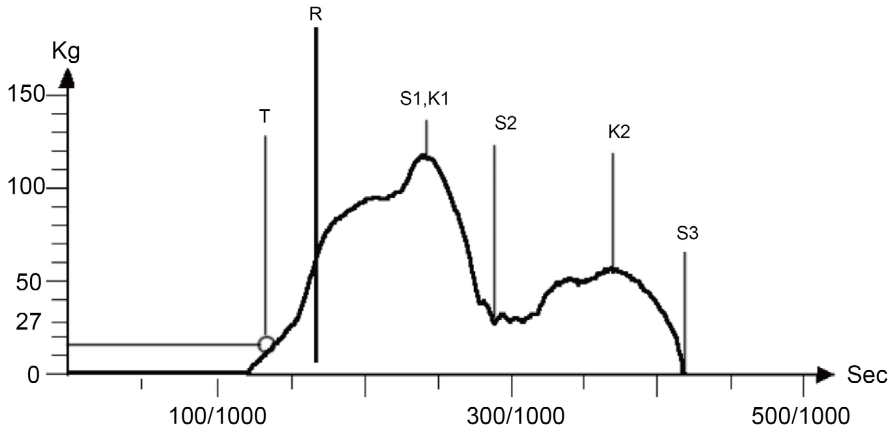

Figure 1. Typical starting pressure curve. Note: S1: time of athlete hand-lifting; S2: time of back foot leaving; S3: time of front foot leaving; R: reaction time; T: order; K1: the maximum pedal force generated by the hand leaving the ground; K2: the pedal force generated by the front foot leaving the ground.

2.2.2. Method of Data Processing

All data are processed with SPSS18.0 for Windows Chinese version and Excel 2013 data processing software.

Analysis of univariate (ANOVA) (Lai & Chen, 2010): The pedal pressure and time of the top eight athletes' ROUND 1, SEMIFINALS, FINAL in the female 100m at the 2010 Guangzhou Asian Games were analyzed with the way of Least Significant Difference (LSD) to clarify the comparison of various indicators among the Asian female athletes of 100m at the current stage.

Correlation analysis (Lai & Chen, 2010): The "bivariate correlation analysis" of pedal pressure and time of the top eight athletes' ROUND 1, SEMIFINALS, FINAL of the women's 100 m at the 2010 Guangzhou Asian Games was conducted to clarify the correlation between various indicators among the Asian female 100 m athletes at the present stage.

3. Results

Pressure-time curve refers to the curve of the ground kick force and time change of the athlete from "on the mark-ready-order" to get away from the starter. Usually the athletes start to press the starting device after hearing the order, whose body gradually extends from the "tucked" posture, with the angle of both knee joint gradually expands, the human body does accelerated movement (Zhang & Zhan, 2014). At this time, the reaction force of human body mass is opposite to the direction of human body movement, so the "pressure" gradually increases. When the pressure curve reaches the highest point (K1), the human body slows down. When slowing down the movement, the reaction force of human body mass is consistent with the direction of human body movement, reducing the pressure on the starting device, and the curve is gradually downward. When the curve drops to S2, it reaches the lowest point of the first peak of the curve movement, indicating that the athlete's back foot kicks off the starter (the

first parabolic curve). Then the athlete front foot with single support, the knee joint from small to large, does acceleration and deceleration movement, then appeared the second parabolic curve, which is less in height than the first parabolic curve because the curve is completed by the athlete in a single support state. When it drops to S3, the athletes completed the starting power process and entered the flying stage.

Athlete starting quality and training is directly proportional, the more regular and effective training in the process of starting, the more stable the data obtained in the sprint starting training. If measurement of the response obtained through the naked eye or instruments only, simply attributing the speed of the starting response to the length of the athlete's physiological response, starting training will make directional errors. In the starting training, coaches should first clearly understand that the main reason for the difference in the starting reaction of different athletes is the duration of their reaction exercise. Secondly, it is necessary to make a comprehensive analysis on the data in the monitoring system, know the individual differences of different athletes and find out the main reasons for their starting response.

3.1. Fitting Figure of Pressure-Time Curves for Each Athlete in ROUND 1(R), SEMIFINALS (S), and FINAL (F)

The pressure-time curve of the top 8 athletes of Women's 100 m dash at the 2010 Guangzhou Asian Games was recorded respectively as the follows (shown as Figure 2): Track 1 (No. 421), Track 2 (No. 925), Track 3 (No. 943), Track 4 (No. 439), Track 5 (No. 129), Track 6 (No. 870), Track 7 (No. 143), Track 8 (No. 938).

3.2. Mean Value and Standard Deviation Analysis of Time, K1, S1, S1, S2, S3, K2, and R Values for Each Athlete

During the starting process, due to the difference in strength, technical movements and time required by each person, the pressure curve formed in the monitoring system is also different, and the study compares the average and standard deviation of the time, K1, K1, S1, S2, S3, K2, and R values of 8 athletes, and then identifies problems to help athletes improve.

The time is the outcome of the athletes in each event. As can be seen from Table 1, the athletes' outcomes gradually improve along with the progress and importance of the competition.

K1 is the peak power of an athlete kicking back on both legs. According to Table 2, although the strength of the back legs varies, the average peak strength of the back legs of the athletes increases with the progress and importance of the race.

S1 is the time when the back-kick peak power of both legs. It can be seen from Table 3 that, on the whole, the peak strength of the first round is not much different from that of the semifinal S1, but in the final, S1 is significantly reduced, and the importance of the competition has a great impact on S1.

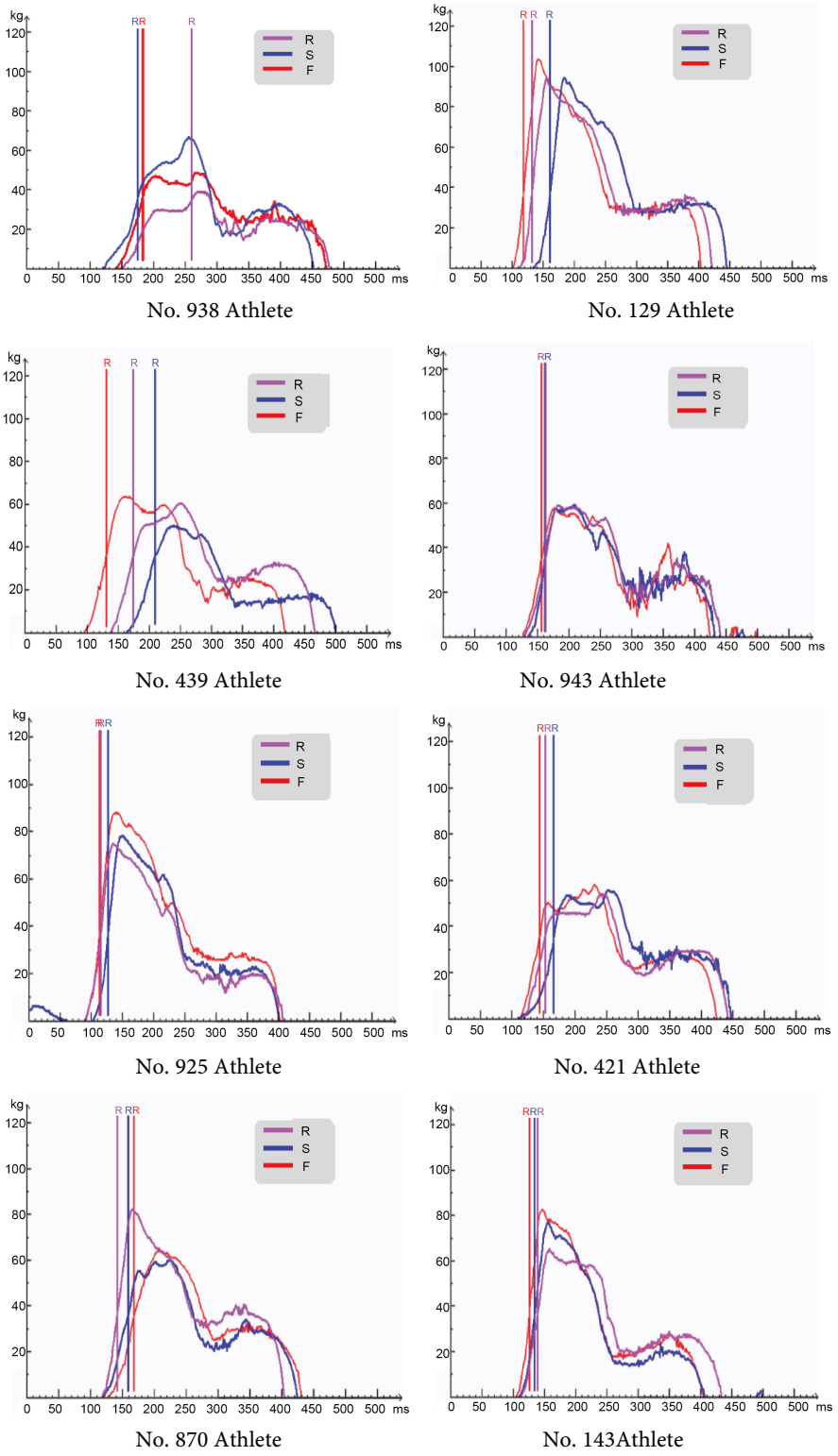

Figure 2. Pressure time curve fitting diagram of the top 8 athletes.

The S2 is the time of athletes' back foot to the starter. According to **Table 4**, the time of the hind legs away from the starter varies greatly among athletes. But overall, S2 takes the least time in the final.

Table 1. Mean value and standard deviation of time for each athlete.

	938	129	439	943	925	421	870	143	$\overline{x}$
ROUND 1	11.85	11.74	11.78	11.56	11.54	11.41	11.64	11.84	11.67
SEMIFINALS	11.65	11.65	11.59	11.46	11.36	11.32	11.61	11.77	11.55
FINAL	11.76	11.63	11.5	11.43	11.34	11.33	11.68	11.71	11.55
$\overline{x}$	11.75	11.67	11.62	11.48	11.41	11.35	11.64	11.77	11.59
S	0.10	0.06	0.14	0.07	0.11	0.05	0.04	0.07	0.07

Table 2. Mean value and standard deviation of K1 value (kg) for each athlete.

	938	129	439	943	925	421	870	143	$\overline{x}$
ROUND 1	35	94.5	51	59.8	86.5	46.5	81.5	66	65.1
SEMIFINALS	55	95	50.2	58.5	79.5	54	56	77	65.7
FINAL	39.2	105	63	59	89.5	50.5	66	83	69.4
$\overline{x}$	43.07	98.17	54.73	59.10	85.17	50.33	67.83	75.33	66.7
S	10.55	5.92	7.17	0.66	5.13	3.75	12.85	8.62	8.2

Table 3. Mean value and standard deviation of S1 value (ms) for each athlete.

	938	129	439	943	925	421	870	143	$\overline{x}$
ROUND 1	287	153	197	185	135	216	169	159	187.6
SEMIFINALS	221	184	242	181	150	191	178	157	188.0
FINAL	205	144	168	176	145	159	209	148	169.3
$\overline{x}$	237.67	160.33	202.33	180.67	143.33	188.67	185.33	154.67	181.6
S	43.47	20.98	37.29	4.51	7.64	28.57	20.98	5.86	21.2

Table 4. Mean value and standard deviation of S2 value (ms) for each athlete.

	938	129	439	943	925	421	870	143	$\overline{x}$
ROUND 1	342	287	322	292	315	312	281	292	305.4
SEMIFINALS	309	309	382	311	295	352	295	287	317.5
FINAL	348	322	292	309	299	297	295	277	304.9
$\overline{x}$	333.00	306.00	332.00	304.00	303.00	320.33	290.33	285.33	309.2
S	21.00	17.69	45.83	10.44	10.58	28.43	8.08	7.64	18.7

S3 is the time when the front leg, or the athlete kicks off the starter. According to Table 5, S3 varies among athletes, and overall, S3 is the smallest in the final.

K2 is the maximum strength of an athlete kick-off of the front leg, which is also the maximum strength of an athlete on one leg. According to Table 6, K2 varies among athletes, and overall, K2 is the largest in the final.

As shown from Table 7, K1 showed a significant correlation with S1, S2, S3 and R, and was not significantly associated with K2. S1 did not show a significant correlation with S3 and K2, but significant with all other parameters. S2

Table 5. Mean value and standard deviation of the S3 value (ms) for each athlete.

	938	129	439	943	925	421	870	143	$\overline{x}$
ROUND 1	478	422	414	491	407	444	405	432	436.6
SEMIFINALS	452	445	498	432	400	498	426	406	444.6
FINAL	461	405	418	425	402	424	433	405	421.6
$\overline{x}$	463.67	424.00	443.33	449.33	403.00	455.33	421.33	414.33	434.3
S	13.20	20.07	47.38	36.25	3.61	38.28	14.57	15.31	23.6

Table 6. Mean value and standard deviation of K2 value (kg) for each athlete.

	938	129	439	943	925	421	870	143	$\overline{x}$
ROUND 1	28	38	33.5	36	20.2	30.1	40.1	29.7	32
SEMIFINALS	33	43	19.5	39	24	31.5	34.5	23	30
FINAL	35	35	26.5	41.5	29.6	29.7	32.8	27.5	32.2
$\overline{x}$	32	38.7	26.5	38.8	24.6	30.4	35.8	26.7	31.7
S	3.61	4.04	7.00	2.75	4.73	0.95	3.82	3.42	3.8

Table 7. "Bivariate correlation" results of each athlete.

	K1	S1	S2	S3	K2	R
K1		−0.710**	−0.472*	−0.599**	0.094	−0.708**
S1	−0.710**		0.613**	0.0722	−0.12	−0.954**
S2	−0.472*	0.613**		0.678**	−0.213	0.630**
S3	−0.599**	0.0722	0.678**		0.1	0.734**
K2	0.094	−0.12	−0.213	0.1		0.041
R	−0.708**	−0.954**	0.630**	0.734**	0.041	

**Significant correlation at the 0.1 level (bilateral), and *significant correlation at the 0.05 level (bilateral).

showed significant associations with K1, S1, S3 and R, and did not associate significantly with K2. S3 showed significant associations with K1, S3 and R, but not significant with S1 and K2. K2 was not significantly correlated with all of the parameters. R showed a significant correlation with K1, S1, S2 and S3.

4. Analysis and Discussion

4.1. Variables Differ in Different Competitions

The mean of all variables was the best at the final. In the final, the athletes' nerve excitability and back pedal strength will be strengthened with the importance of the competition and athletes' seriousness to the competition. K1 reflects the maximum strength of an athlete when kicking back on both legs. It shows that with the increasing importance and intensity of the competition, the backpedal strength of the athletes will also increase. S2 and S3 are significantly associated with K1, and as the maximum strength of the athlete increases, the instantane-

ous acceleration also increases, thus reducing the time for the hind legs to push off the starter, thus ultimately reducing the overall time of pushing off the starter. R is significantly associated with K1, because the increase in K1 reduces the value that the athletes reach the pressure threshold set by the starting pressure monitoring system, causing the overall minimum starting response in the final. Although K2 also reached the highest value in the final, it is not related to the starting speed.

4.2. Significant Differences in Strength and Explosive Power between Different Athletes

Burst force is the form of speed force and is the ability of strength and time together, which is characterized by muscle contraction before fiber is stretched and result in muscle stretching pressure, improving the contraction rate while increasing muscle contraction amplitude, thus increase time gradient of muscle tension (Wu & Huang, 1993). Explosive force should be measured by the time gradient of force, that's to say, explosive force refers to the body plays the maximum muscle tension in a very short period of time under the condition of overcoming certain resistance, is a kind of force acceleration (Xie, 2016). According to the comparison of data between **Table 3** and **Table 2**, faster athletes had significantly greater explosive power than those with slower speed, athletes with large K1 values have smaller S1 values, and athletes with small K2 values have larger S1 values. The analysis showed: to get a fast starting time in a short time need to apply a large explosive force to the starter. The stronger the explosive force, the less time it takes.

4.3. There Are Differences in the Starting Stability of the Athletes

By comparing K1 and K2 data with **Figure 2**, No. 421 athlete has the smallest changes in K1 and K2, with the standard deviation of 3.75 and 0.95 respectively, which reflects the most stable movement in the starting process; No. 938 athlete has the largest change in K1 and K2 with the standard deviation of 10.55 and 3.61 respectively. Through the curve fitting of **Figure 2**, it indicated the starting reaction is more variable and the waveform image is unstable. Starting time is the time used for the athletes to complete the start movements, which is closely related to the athletes' technical movements and physical quality (Luo, Xie, & Du, 2012). Therefore, the starting stability and starting speed improvement of the athletes in different races are an important indicator for the athletes to master the starting technology proficiency. When the athletes master well the starting movement, the starting stability and speed change of their starting posture and methods will be significantly different.

4.4. The Coordination of Both Legs Back-Pedal Is the Key to the Starting Technology

K2 reflects the maximum strength of the athlete when stepping back on one leg, which was not significantly correlated with all of the parameters. In this period,

the athlete kicks back on one leg and does not involve the synergy of the legs, so it can intuitively reflect the athlete's leg strength. According to Table 6, K1 was not significantly associated with K2, indicating that the backpedal strength of both legs were not associated with that of the single leg. The starting speed not only needs the strength of the athletes, but also needs the athletes to have a reasonable starting technology, so that the synergy athletes' legs back-pedal is strengthened, thus increasing the value of K1, and finally get a good starting speed. Only by strengthening the coordination of both legs' back-pedal and improving K1 can we finally improve the starting technology.

5. Conclusions and Suggestions

The results show that: 1) in the women's 100 m sprint event of the 16th Asian Games, the starting response parameters of female athletes increase correspondingly with the increase of the importance of the competition; 2) The peak strength of the athlete's leg back pedal is a key factor affecting the athlete's starting point, and the change of the curve of the sports start tests whether the athlete has been trained for a long time to ensure the stability of the starting posture; 3) The main problem of slow reaction of athletes is low explosiveness. Strength and explosiveness are important factors that cause the significant difference in pedaling time (reaction action time) of athletes of different levels, and athletes with slower starts can strengthen the training of theory and explosiveness; 4) The synergy of the athlete's leg back pedal is the main reason for the peak strength of the back pedal of the leg, and athletes can only achieve the ideal starting effect after repeated teaching, training and competition practice, mastering the synergy of the back pedal of the legs, enhancing the stability of the starting and improving the starting technique.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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