Biomechanical parameters of running technique of sprint athletes-finalists of world championship

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Abstract

Objective of the study: to compare the spatio-temporal, kinematic and angular characteristics of the distance running technique of the strongest 100 and 200 m sprinters in the world.

Methodology of the study. The study analyzed the data of the spatio-temporal, kinematic and angular characteristics of distance running presented in the IAAF biomechanical report of the men's 100m and 200m finals of the 2017 World Athletics Championships.

Results of the study. In the middle of a straight line in a 100 m run, the average speed is 11,60±0,06 m/s, in a 200 m run – 10,31±0,09 m/s. The difference in speed is achieved due to the step rate (4,80±0,08 stride/s and 4,27±0,05 stride/s, respectively, $p \leq 0{,}05$), because the stride length at both distances is identical and is equal on average to 2,42 m (Table 1). A high step rate per 100 m is achieved due to the shorter time of the contact time (0,093±0,002 s and 0,103±0,002 s, $p \leq 0{,}05$) and flight time (0,116 ±0,002 s and 0,132±0,003 s, $p \leq 0{,}05$). When placing the leg on a support, reliably significant differences ($p \leq 0{,}05$) are observed in the angle of inclination of the body, the angle between the thigh of the swinging leg and the vertical line. When removing the leg from the support, a reliably significant difference ($p \leq 0{,}05$) is observed in the angle of inclination of the body and the angle between the lower leg of the supporting leg and the horizontal line.

Keywords: *sprint running, sprint running technique, 100 m and 200 m running, spatio-temporal and kinematic characteristics of running, biomechanical parameters of sprint running.*

Introduction. Effective technique is one of the key components in achieving a high competitive result in sprint running. The study and comparison of its parameters among the strongest sprinters in the world makes it possible to identify the relations of individual links of technique, to form model characteristics. The data obtained in the work can be used in the preparation of runners at various distances of sprint running, in the selection and development of training means, exercises, which are close in spatio-temporal characteristics to the competition form.

Objective of the study: to compare the spatio-temporal, kinematic and angular characteristics of the distance running technique of the strongest 100 and 200 m sprinters in the world.

Study methods and organization. In our study, we used data from the biomechanical report of the IAAF (International Association of Athletics Federation) of the men's 100 m and 200 m finals at the 2017 World Athletics Championships in London [3,4]. The report presents the results of a video analysis carried out for the 100 m run in the range from 47 m to 55 m, for the 200 m run at the 150 m mark. A comparison of the spatio-temporal and angular characteristics of the running technique of the men's 100 m and 200 m finalists was made. Statistical data processing was carried out using the Statgraphics Centurion software, the validity of differences was determined by Student's t-test for independent samples.

Study results and their discussion. The main characteristics that determine the speed of movement along the distance are the length and step rate. The higher the length and step rate, the higher the running speed. The average values of the length of the running stride in the 100 m and 200 m sprints are identical – 2,42 m. The minimum values for 100 m are

2,26 m, for 200 m – 2,29 m, the maximum values are 2,70 m and 2,60 m, respectively. It should be noted that since in the 100 m run the measurements were carried out on the interval from 47 to 55 m, when there is still some increase in the running speed, i.e. starting, it can be assumed, there are even greater maximum stride length values. The step rate at 100 m is significantly higher than at 200 m, 4,80±0,08 s and 4,27±0,05 s, respectively, p≤0,05. The time of the supported and unsupported periods of the running stride cycle in running is statistically less by 100m than by 200 m, p≤0,05, but in unsupported step this difference is more significant. The range of values of the supported period for 100 m lies within 0,08–0,09 s, for 200 m – 0,09–0,10 s; unsupported period for 100 m – 0,11–0,12 s, for 200 m – 0,13–0,15 s. The stride length-to-height ratio of a runner at both distances is approximately the same and has an average value of 1,31–1,33.

At the beginning of the contact period, the horizontal distance between the ground contact point at touchdown and the CM (centre of mass) does not have statistically significant differences (p>0,05) and is within 0,28–0,48 m. At the end of the contact period, the average horizontal distance between the ground contact point at toe-off and the CM is significantly greater by 100 m (0,62±0,01 m) than by 200 m (0,56±0,01 m), p≤0,05.

The study analyzed the angular characteristics of runners at the moment of placing the leg on the support and removing it from it (Figure 1): the angle of inclination of the trunk relative to the horizontal line (α), the angle of flexion of the knee joint (β), the angle between the vertical line and the hip of the swing-up leg (ζ), the angle between the swing-up and support legs (η), the angle of inclination of the lower leg/calf of the support leg relative to the horizontal line (θ), the angle of the ankle joint of the support leg (I).

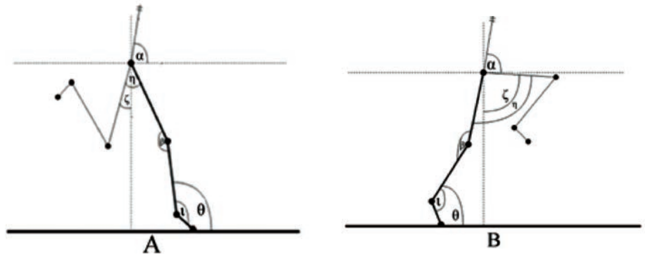

Figure 1. *Body schematic angles at touchdown (A) and toe-off (B)*

In the practice of training sprinters, many coaches pay attention primarily to the height of the hip raise (angle ζ) and extension of the support leg at the knee joint (angle β) at the moment of take-off, usually giving the setting for maximum flexion of the swing-up leg hip and extension of the support leg. The study of these values among the world's leading sprinters shows that the average value of the angle ζ for the 100 m run is 67,6±2,3°, and for the 200 m run is 60,6±2,8° (p> 0,05). The angle of flexion of the knee joint (β), despite the similarity of the mean values at both distances, has a significant scatter of values. At the moment of placing the foot, its minimum value for the 100 m sprint is 143° for the sprinter who took the eighth place and 144° is the second, maximum 168°, for 200 m the minimum and maximum values are 149° and 175°, respectively. When pushing off in a 100 m run, the range of values is from 138° to 160°, in 200 m from 141° to 170°. It is important that in addition to the large scatter of values in this indicator among the studied groups, some sprinters have a difference of more than 20° when comparing the angles in the left and right legs, which shows the existing asymmetry of motor actions even among the top-class sprinters.

Another, no less important characteristic of running, is the position of the foot when it is placed on

Table 1. Spatio-temporal characteristics in running at the 100 m and 200 m distances among the world-class sprinters

		Result	Time reaction (s)	Step rate (stride/s)	Step length (m)	Velocity (m/s)	Step length/heigth	Contact time (s)	Flight time (s)	Distance from the ground contact to the body CM (m)	
										Touch-down	toe-off
100m (n=8)	$\bar{x} \pm S_{\bar{x}}$	10,04± 0,04	0,155± 0,111	4,80± 0,08	2,42± 0,05	11,60± 0,06	1,33± 0,01	0,093± 0,002	0,116± 0,002	0,38± 0,01	0,62± 0,01
	σ	0,12	0,033	0,22	0,14	0,16	0,03	0,004	0,007	0,04	0,04
200m (n=8)	$\bar{x} \pm S_{\bar{x}}$	20,31± 0,08	0,156± 0,003	4,27± 0,05	2,42± 0,03	10,31± 0,09	1,31± 0,02	0,103± 0,002	0,132± 0,003	0,41± 0,02	0,56± 0,01
	σ	0,23	0,009	0,15	0,09	0,25	0,06	0,006	0,008	0,04	0,03
p			>0,05	≤0,05	>0,05	≤0,05	>0,05	≤0,05	≤0,05	>0,05	≤0,05

Table 2. *Angular characteristics in 100 m and 200 m distances running for world-class sprinters*

			Touchdown (°)						Toe-off (°)					
		Result	α	β	ζ	η	θ	(I)	α	β	ζ	η	θ	(I)
100m (n=8)	$\bar{x} \pm S_{\bar{x}}$	10,04±0,04	75,1±1,0	156,2±2,1	17,1±2,8	9,7±3,7	97,9±1,1	115,9±1,1	80,4±1,2	153,8±1,4	67,6±2,3	93,1±2,4	38,4±0,6	138,5±1,1
	σ	0,12	3,0	6,1	7,1	10,6	3,0	3,1	3,3	4,1	6,6	6,9	1,6	3,0
200m (n=8)	$\bar{x} \pm S_{\bar{x}}$	20,31±0,08	81,5±1,2	159,1±1,6	6,6±2,9	17,1±3,1	99,9±0,9	114,9±1,6	84,3±0,5	157,8±1,6	60,6±2,8	86,1±2,8	43,1±0,6	131,4±3,5
	σ	0,23	3,5	4,7	8,1	8,6	2,6	4,5	1,5	4,5	7,8	7,8	1,7	9,9
p			≤0,05	>0,05	≤0,05	>0,05	>0,05	>0,05	≤0,05	>0,05	>0,05	>0,05	≤0,05	>0,05

the support. The angle of the ankle joint (θ) at the moment of touching the running track at both distances is on average 114–115° (p>0,05), i.e. the heel is slightly above the surface of the track. The lower leg is placed almost vertically, the angle θ slightly exceeds 90°, the average values are 97-99° (p>0,05). At the same time, the angle of inclination of the trunk (α) for the 200 m run is significantly higher both when the legs are set (81,5±1,2°) and when pushing off (84,3±0,5°).

It is generally accepted that the strongest sprinters are distinguished by the ability to quickly "bring their legs together", which is characterized by the location of the swing-up hip next to or even in front of the support leg at the time of its placing. It means that the angle η should be near zero. However, according to biomechanical data, both the gold and silver medalists of the 100 m race has their swing-up leg behind the support leg at an angle of 24–28°. Usain Bolt, the bronze medalist, world record holder for 100 m and 200 m, his support left leg has a swing-up leg at 21° behind, and when placing the right leg - the left is in front by 4°. For the rest of the participants in the finals, the values are in the range from 0 to 11°, while only in one case the swing-up leg is in front of the support leg, by 7°. In the 100 m sprint, all sprinters have the swing-up leg in front of the vertical line, the average angle ζ 17,1±2,8°. The same is observed among the runners who took from the first to the fourth places in the 200 m race (angle ζ from 7° to 19°). The calculation of the correlation coefficients did not reveal a reliably significant relation (p>0,05) between the investigated angular and space-time characteristics.

Conclusion. Comparison of the spatial-temporal and angular characteristics of the world's leading 100 m sprinters (47–55 m segment) and 200 m (150 m segment) sprints showed that reliably significant differences were observed in the running speed (11,60±0,06 m/s and 10,31±0,09 m/s), cadence (4,80 ± 0,08 stride/s and 4,27±0,05 stride/s), contact (0,093±0,002 s and 0,103±0,002 s) and flight (0,116±0,002 s and 0,132±0,003 s) periods of the running strides, the horizontal distance between the ground contact point at toe-off and the CM (0,62 ±0,01 m and 0,56±0,01 m), p≤0,05. When comparing the angular characteristics, reliably significant differences (p≤0,05) are observed in the angle of inclination of the trunk (α), in both studied phases, the angle of inclination of the lower leg when removing the leg from the support (θ).

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