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ELITE MALE AND FEMALE SPRINTERS' BODY BUILD, STRIDE LENGTH AND STRIDE FREQUENCY

Key words: sprint, stride length, stride frequency.

ABSTRACT

Different authors and coaches have been trying to find optimal parameters of sprint strides to improve runners' speed. In this study the authors discuss which of the stride parameters (length or frequency) has the greatest impact on 100-m results. The study was carried out on a sample of 109 men and 79 women elite sprinters taking part in the 2003 World Championships in Paris. The research revealed that stride frequency decided about the results of the elite female sprinters, while the stride length was the most important stride parameter in male sprinters. Taller male sprinters obtained better 100-m run results. Body mass and body height significantly influenced the stride parameters – the bigger the body mass and height, the longer the strides and the lower stride frequency of the competitors. The research results point to diversity in sprint training programs for men and women.

INTRODUCTION

Studies on 100 m runs have mainly focused on changes of speed and parameters of sprint strides [2, 6, 19, 20, 26]. Most of these studies have been carried out during the most prestigious athletic contests such as Olympic Games or World Championship. In competitive conditions a 100-m sprint run consists of such elements as sport, pure acceleration, transition, maximum velocity and deceleration [11]. Reaction time, stride length and stride frequency have the greatest impact on the results in this shortest of sprint races [3, 11].

However, Martin and Buoneristinani [17] claim that in the group of world elite sprinters the reaction time has no influence on the results of the 100 m race. The majority of authors claim that from the biomechanical point of view the most important factors affecting sprint results are stride length and frequency. Bartonietz [1] investigated the problem of stride in Bernstein's studies from 1930. Studies carried out during the World Championships [6, 20] and Olympic Games [2] show that the stride length and stride frequency were highly individual for each top-level sprinter [22].

A comparative study by Deriex [4] showed that differences in stride length and frequency among young runners and world class sprinters depended on muscular strength. Donati [5] and Parodisis and Cooke [22] tried to find methods of improvement of both parameters of sprint stride. Donati [5] developed a complex set of sprint exercises leading to improvement of stride length or stride frequency. Paradisis and Cooke [22] showed differences of both parameters in uphill and downhill sprint runs.

The aim of this study was to determine which of the stride parameters (length or frequency) had the greatest effect on 100 m results. The correlation between the race results, stride length and frequency and sprinters' body build was also analyzed.

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MATERIAL AND METHODS

The subjects were 79 female and 109 male sprinters participating in the 2003 World Championships 100 m run. Their profiles are shown in Table 1.

Table 1. Time of 100-m run, body build and stride parameters of sprinters taking part in the 2003 Paris World Championships

Parameter		$\bar{x}$	SD	min.	max
100 m time (s)	M	10.28	0.21	10.01	11.03
	F	11.27	0.21	10.85	11.93
Height (cm)	M	179.23	5.37	160	188
	F	167.15	5.7	158	182
Body mass (kg)	M	76.38	5.93	60	88
	F	58.49	4.56	50	67
Rohrer index	M	1.33	0.09	1.15	1.71
	F	1.25	0.09	1.0	1.45

All 100 m races, from heats to finals, were recorded on a video tape. On the basis of the recording the number of competitors' strides was calculated by two independent experts (athletic coaches). If results differed the final number of strides was obtained in the second trial. The number of strides was calculated with the accuracy of ¼ of stride length. Parts of the last stride were assessed according to 1 m finish lines. Similar procedures were used by Vittori and Donati (lines in 100 and 110 m hurdles) in their analysis of 100 m run during the Olympic Games in Munich, and by Letzelter [14, 26]. Letzelter [14] set measurement errors in a similar group of international sprinters: 0.25% for stride length and 0.50% for stride frequency. Thanks to these procedures an analysis of the whole 100-m distance without dividing it into sections became possible. Previous studies [2, 6, 20, 21, 27] also faced this problem but in small (only winners of finalists) groups of sprinters. After that the average stride length and frequency were calculated the time of run was assessed using data from the official World Championships bulletins [18]. The same procedure was used by Quinn [24] in his study.

Subjects' basic body build parameters (height and body mass) were provided by the International Amateur Athletic Federation (IAAF). Then Rohrer index[1] for each sprinter was calculated. This somatic indicator is not only the simplest but also a very useful parameter of body build type. In his study of top level Polish hurdlers Iskra [9] noted that the RI differentiated between "faster" and "slower" sprinters. Then male and female sprinters were divided into two groups according to their sports level ("faster" and "slower"). The "faster" group of sprinters reached time below the statistical mean (10.28 s for men and 11.27 s for women); the "slower" group of runners needed more time to cover the distance.

Pearson correlation was used to determine the connections between body build, stride length and frequency and 100 m run results. Student's t-test was used to determine the significance of changes between the "faster" and "slower" groups.

RESULTS

The analysis revealed a statistically significant correlation between the results and the stride frequency in the group of female sprinters ($r = –0.39$, $p \leq 0.01$). The correlation between stride length and the race results was statistically insignificant (Table 2).

In the group of male sprinters the relation was opposite: stride frequency was not correlated with the race results, while the stride length had the greatest impact on the sport level in the 100 m race ($r = – 0.43$, $p \leq 0.01$). Body height has a significant influence on the running stride length as well as on the stride frequency in both groups – men and women – regardless of their sport level (Table 2).

[1] RI = [body weight (g) / body height^3 (cm)] x 100

Table 2. Correlation factors between running stride length and frequency, body build and the sport level in 100-m race

Parameter		Stride length			Stride frequency		
		Total	"Faster"	"Slower"	Total	"Faster"	"Slower"
100-m race result	F	–0.05	–0.13	–0.22*	–0.39**	–0.36**	–0.14
	M	–0.43**	–0.13	–0.46**	–0.13	–0.06	–0.07
Stride length	F	-----------	-----------	----------	–0.89**	–0.97**	–0.93**
	M				–0.84**	–0.98**	–0.86**
Stride frequency	F	–0.89**	–0.97**	–0.93**	-----------	-----------	-----------
	M	–0.84**	–0.98**	–0.84**			
Height	F	0.59**	0.67**	0.55**	–0.61**	–0.68**	–0.51**
	M	0.56**	0.40**	0.65**	–0.40**	–0.40**	–0.51**
Body mass	F	0.45**	0.58**	0.29*	–0.41**	–0.57**	–0.23*
	M	0.49**	0.50**	0.52**	–0.42**	–0.49**	–0.45**
Rohrer index	F	–0.34*	–0.32*	–0.42**	0.40**	0.35*	0.41**
	M	–0.22*	0.17	0.41**	0.05	–0.15	0.25*

* – $p \leq 0.05$, ** – $p \leq 0.01$

Body mass significantly influences the stride length and frequency in the "faster" male group (<11.27 s/ /100 m). In the "slower" group of female athletes, there was no correlation between body mass and the running stride parameters. In the male group body mass had a statistically significant impact on the running stride length and frequency regardless of the race result. The study results were verified with Student's t-test in the groups of "faster" and "slower" sprinters (Table 3). The fastest male sprinters ($\bar{x}$ = 10.15 ± 0.07) usually had longer running strides than the slower runners ($\bar{x}$ = 10.46 ± 0.20), ($p \leq 0.01$). The best female sprinters ($\bar{x}$ = 11.11 ± 0.10) had a higher ($p \leq 0.01$) stride frequency than the slower ones ($\bar{x}$ = 11.43 ± 0.16 s).

DISCUSSION

As it was shown in earlier studies, results in sprint races depend on several factors. According to Kraaijenhof [13] there are four factors affecting the 100 m run results: body build, neuro-muscular system, biochemical and physiological adaptation to short-term efforts and biomechanics. The biomechanical efficiency is one of the three components (the other two being metabolic system and neurological efficiency) of speed distinguished by Huntington [8].

The complex character of biomechanical sprint running was noticed by Mero [19] in his comprehensive study, in which apart from the kinetic, kinematic and dynamic parameters the most important turned out to be the stride length and stride frequency.

In a review study of sprint stride parameters Letzelter [14] presented research results from 1963 (Grundlach) to 1980 (van Coppendle et. al.) One of the basic problems of proper training preparation of sprinters is finding the optimal (in terms of biomechanical parameters) running stride. In their study of kinematical and kinetic characteristics of sprint running Plamondon and Roy [23] noticed that modification of sprint velocity was greatly affected by the simplest stride parameters.

Letzelter's comparative analysis [14] revealed that the top 100-m sprinters in the 1997 and 1999 World Championships had longer strides (especially women) and insignificantly lower stride frequency (0.7 – 2.5%).

Analyses of kinematical, kinetic and dynamic parameters of the sprint stride have proven that the basic and most commonly used parameters are stride length and stride frequency [4, 16, 22].

Studies of sprint stride parameters are important in terms of practical aspects of sports preparation of high-level sprinters. Coaches, sometimes instinctively, used exercises increasing both stride length and stride frequency [5, 10, 12]. After an experiment in a group of Italian National Team sprinters Donati [5] prepared a list of exercises to improve the sprint stride parameters.

Earlier studies showed that elite sprinters had a good combination of stride length and stride frequency. They showed that the "sprint pattern" was more of an individual matter [25] rather than based on a combination of somatic parameters. The studies of elite male and female sprinters revealed that stride length and frequency were different in male and female sprinters (Tables 2 and 3).

A characteristic feature of the best female sprinters is the high stride frequency, also called “rhythm”; whereas long strides are a feature of the fastest men athletes – (Tables 2 and 3).

(RI – 1.32-1.34), while women-sprinters were slim (1.23-1.27). These norms, however, concern the whole population, not just specific groups of athletes.

There is a significant correlation between the body mass of high-level sprinters and hurdlers and their muscle mass [9], which means that the basic parameters of sprint strides depend on both height and body mass.

Table 3. Significance of differences between 100-m race results, body build and running stride parameters of female and male sprinters of various sports levels

Parameter	Women			Men		
	“Faster”	“Slower”	p	“Faster”	“Slower”	p
100-m race result (s)	11.11 ± 0.10	11.43 ± 0.16	0.001	10.15 ± 0.07	10.46 ± 0.20	0.001
Stride length (cm)	203.04 ± 7.41	203.20 ± 8.04	NS	219.31 ± 6.83	213.92 ± 7.12	0.01
Stride frequency (1/s)	4.44 ± 0.17	4.31 ± 0.17	0.01	4.49 ± 0.14	4.46 ± 0.15	NS
Height (cm)	166 ± 5.33	168.39 ± 5.89	NS	180.17 ± 4.5	177.79 ± 6.34	0.05
Body mass (kg)	58.17 ± 4.54	58.84 ± 4.61	NS	76.95 ± 5.72	75.5 ± 6.38	NS
Rohrer index	1.27 ± 0.78	1.23 ± 0.96	NS	1.32 ± 0.08	1.34 ± 0.09	NS

* – $p \leq 0.05$, ** – $p \leq 0.01$, NS – non-significant

The analysis results point to a differentiation in the sprint training program for men and women. Stride frequency decides about the results of elite female sprinters in 100m races ($r = -0.39$, $p \leq 0.01$), while the stride length is the most important parameter for male sprinters ($r = -0.43$, $p \leq 0.01$). Letzelter [14] showed that from 1972 to 1999 the world top male sprinters increased their stride length by 7 cm, while female sprinters by 9 cm. Our study showed that the following four years of sprint races brought no changes to this parameter (both in men and women). From 1972 to 1999 the stride frequency decreased from 0.061/s (women) to 0.011/s (men). This tendency was also maintained during the following four years. It can be concluded that changes in world class sprint runs concerned increasing of stride length. In the group of world class male sprinters stride length remains a basic parameter of sprint strides, which is significant in sprinters’ technical training.

The significant correlation ($p \leq 0.001$) between sprint stride (both length and frequency) and body built shows that elite sprinters must be tall and of stronger build. “Faster” men were taller than “slower” men ($p \leq 0.05$); “faster” women were shorter (NS) but of stronger build. According to Malinowski and Bożiłow [15] the world-class sprinters are of medium (athletic) type of body built

From the coaches’ point of view the body mass, specially muscle mass, is crucial in the acceleration phase (in increasing the stride length), and body height in the second part of run, during maintaining the stride length [10, 12, 13].

The study of Mero and Komi [19] showed differences in stride length and frequency in sprint runs of various speeds (submaximal, maximal and supramaximal). They proved that the increase of the running speed over maximal runs depends, first of all, on stride length. To improve stride frequency coaches must introduce special drills (skips) into their training sessions.

The coaches of elite sprinters should apply training means according to competitors’ gender. More attention should be paid to stride frequency exercises in the female sprinters’ training program and to training measures lengthening the running strides of male sprinters. Most coaches still prefer simultaneous improvement of both stride length and stride frequency.

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