© by IAAF
28:1/2; 35-45, 2013

Kinematics of Sprinting in Children and Youths

by Marian Vanderka and Tomáš Kampmiller

ABSTRACT

This study deals with ontogenetic characteristics of basic kinematic parameters of the running stride in terms of age and gender. Early identification of talent is important for the development of sprinters. Ideally, coaches should understand the parameters of running velocity that are relatively independent of age and demonstrate high individual development, or ontogenetic, stability and thus can be used as predictors of sprinting ability. A sample of more than 2,500 students aged 7 to 18 years sprinted at maximum velocity for 10m with a 15m flying start while kinematic indicators were collected and analysed. Running velocity and stride length were found to be highly dependent on age. However, there was a high ontogenetic stability of other key indicators (stride frequency, duration of support and flight phases), even if these parameters do deteriorate partially in the pre-pubescent period and at the beginning of the pubescent period. Based on their findings, the authors recommend that children and youths be evaluated on the basis of stride frequency and support phase duration. Those with results two or three standard deviations higher than the population averages should be considered as talented and directed to an appropriate programme of training and development.

AUTHORS

Marian Vanderka, PhD, is an Assistant Professor in the Faculty of Physical Education and Sport at Comenius University in Bratislava, Slovakia. He has been an athletics coach for more than 15 years and participated in the 2000 Olympic Games (4x400m) and the 2002 Olympic Games (Bobsleigh).

Tomáš Kampmiller, PhD, is a Professor in the Faculty of Physical Education and Sport at Comenius University in Bratislava, Slovakia. He has coached several Olympic participants in the sprints and hurdles events.

Introduction

Running speed is a basic human motor capability and part of the performance structure in many sports disciplines. It is notoriously hard to develop as it is substantially conditioned by heredity on the levels of the central nervous system, the structure of muscle fibres and the energy systems, all of which are difficult to influence through the process of sports training.

However, the period of the so-called "sensitive phase" in the development of children (9-13 years) is very suitable for the development of sprinting potential. The central nervous system is being developed, particularly the formation of the myelin nerve sheath of the nerves, which serves as a transporter of neural impulses from the central nervous system to active muscles. In this period, the speed of transfer of such impulses, which generate the speed of movement, can be influenced. For this reason, early identification of talent for sprinting and recognition of the kinematic parameters that influence this capability are very important. Ideally, the coach should understand those parameters of running velocity that are relatively independent of age and demonstrate high individual development, or ontogenetic, stability and thus can be used as predictors of sprinting ability.

The zone in a 100m race where sprinters achieve their absolute maximum velocity is very limited. In principle, the best sprinters can sustain this phase for 10 to 20m. This zone is located somewhere between 60 and 80m in top-level men and between 50 and 70m in elite women. It seems that the basic kinematic characteristics of running during the maximum velocity phase are: momentary and average velocity, stride frequency and stride length, duration of the support and flight phases of the stride and the efficiency index, which is defined by the ratio of the durations of the support phase and the flight phase of the stride.

In the maximum velocity phase, both the frequency and the length of the strides are relatively constant and the balance between the duration of the contact or support and the flight phases of the strides is also stabilised. Maximal velocity is always a product of optimal stride length and high stride frequency: research has shown that there are no differences in the stride lengths between elite and sub-elite sprinters and that performance differences are the result of differences in the stride frequency (DONATI, 1996; MACKALA, 2007; SEAGRAVE, MOUCHBAHANI & O`DONNEL, 2009). Stride frequency during the maximum velocity phase is a stable factor in the population ontogenesis and it can be influenced only by appropriately oriented, specialised sport preparation (KORNELJUK & MARAKUŠIN, 1977).

Studies about the kinematics of sprinting are usually focused on high-level athletes and these have found that the most important generator of sprinting stride efficiency is the execution of the support phase, especially the ratio between the breaking phase and propulsion phase of the stride (ĆOH, ŠKOF, KUGOVNIK & DOLENEC, 1994; ALCARAZ, PALAO, ELVIRA & LINTHORNE, 2008). To ensure maximal sprinting velocity, the force impulse must be as small as possible in the breaking phase, which is achieved through an economic placement of the foot of the push-off leg as close as possible to the vertical projection of the body centre of mass on the surface.

It has also been found that there is a linear independence between running velocity and support phase duration (BOGDANOV, 1974; TJUPA ET AL., 1978; KAMPMILLER & KOŠTIAL, 1986). This finding shows that it is a substantial criterion for determining the maximum running velocity of humans. Interestingly, the duration of the support phase in 13 to 16 year-old youths presents a stable factor in terms of ontogenesis (TABAĆNIK, 1979; SIRIS, GAJDARSKA, & RAĆEV, 1983).

The aims of this study were:

- to determine basic kinematic parameters of the running stride over 10m in cross-sectional age samples of boys and girls;
- to point out the ontogenetic stability of stride frequency, stride length, support phase duration and flight phase duration;
- to determine basic measures of location (mean) and of variability (standard deviation) in one-year intervals in samples of boys and girls.

Methods

The subjects were 7 to 18 years-old students from elementary and high schools in Bratislava, Slovakia. There were 1,299 boys and 1,288 girls in the samples. We used no research procedure that might have harmed the children either physically or psychologically and we made special efforts to explain the activities to the parents and be sensitive to any indicators of discomfort in the children.

The subjects were asked to run at maximum velocity over 25m. The velocity for the final 10m (after 15m flying start) was recorded using timing gates in standard conditions (gymnasium, sports hall).

The final segment of the run was carried out on a contact platform that was 17m long and consisted of two conductive layers separated by non-conductive elastic grading. During the contact of a foot with a surface, the platform worked as an electric circuit switch, during the flight phase, the circuit was disconnected.

The contact platform was used in combination with the measuring device "Lokomometer", which through computer technology evaluates basic kinematic parameters of the running stride in the 10m section (velocity, stride frequency and stride length, duration of the support and flight phases and the efficiency index, which is defined by duration of the support phase and the running phase ratio). Stride length parameters measured by "Lokomometer" were calculated according to the method of ŠELINGER & KAMPMILLER (1994).

Measuring of the time variables was carried out with 0.001 sec accuracy, length variables with ± 0.005m accuracy, body height with ± 0.005m accuracy and body weight with ± 0.5kg accuracy. The age of the subjects was determined with 0.1 years accuracy.

The study participants were divided into sample groups according to age with one-year gaps between the groups, on average from 6.5 to 17.5 years old. Means and standard deviations were calculated. Ontogenetic tendencies were represented graphically and by means of significance of difference by two-sample statistical t-test of middle values of inter-annual increase. Statistical significance was evaluated on 1% and 5% level. In addition, a correlation analysis was made with the IBM SSP program.

Results

In Table 1 and Table 2, basic statistical characteristics of the observed parameters can be seen. Figure 1 gives a course of average running velocity, which shows parallel and linear growth from 6.5 to 13.5 years of age in both boys and girls. Later on, velocity in boys increases steeply but stagnates in girls. A similar trend shows on Figure 2 (average stride length). The stride frequency (Figure 3) shows a very stable tendency with slight decrease at the end of observed period. This parameter changes significantly only during pre-pubescence and at the beginning of the pubescent period (from 10.5 to 14.5 years of age).

The duration of the contact of a foot with a surface (Figure 4) displays a course similarly stable to stride frequency. As a result of biological changes, this support phase duration lengthens between 10.5 and 13.5 years of age and gradually returns to the values the values seen at 7 years of age. This parameter of the kinematic structure of the running stride also displays high level of ontogenetic stability, which is proved by interannual t-test values in Table 1, 2.

Values of the flight phase duration can be studied on the Figure 5. Their course is parallel in both boys and girls with duration showing a lengthening tendency until 12.5 years of age followed by slightly shortening tendency until 17.5 years of age. Similar is the course of the efficiency index in Figure 6. It is clear that these parameters duration of the support phase and the flight phase, flight phase and support phase ratio and frequency) confirm a high level of ontogenetic stability (compared to unstable parameters, such as running velocity and stride length, which are dependant on age.

Relationship analysis in the form of Pearson correlation coefficients, which are shown in Table 3, confirms the statistically significant dependence of running velocity, indicators of decimal age, body height, body weight, duration of the support phase and the flight phase, stride length and stride frequency (girls); rela-

Table 1: Statistical characteristics of Age, somatic and kinematic parameters of the maximal velocity sprinting stride over 10m after a 15m flying start and significance of difference between the variables - Boys

Group	Statistic	Decimal Age	Body Height (cm)	Body Weight (kg)	Support Time (ms)	Flight Time (ms)	Stride Length (cm)	Stride Frequency (Strides/sec)	Velocity (m/sec)	Relative Velocity (m.s^{-1})	Relative Stride Length (cm)	Flight/Support (sec)	Statistic
1	Mean	6.50	122.45	22.79	149.10	89.35	114.80	4.24	4.82	2.15	.94	0.60	Mean
n	SD	0.20	4.21	2.86	13.55	14.67	11.81	.33	.40	.30	.09	.11	SD
29	t (1-2)	-13.59	-4.34	-2.59	-.60	-1.35	-4.02	1.60	-2.80	1.05	-2.16	-.98	t (1-2)
	Sig	**0.00**	**0.00**	**0.00**	**0.548**	**0.179**	**0.00**	**0.111**	**0.00**	**0.297**	**0.03**	**0.329**	**Sig**
2	Mean	7.50	127.73	25.13	151.00	94.12	123.99	4.12	5.08	2.08	.97	0.63	Mean
n	SD	0.39	6.26	4.68	15.75	17.78	11.04	.35	.45	.34	.07	.14	SD
137	t (2-3)	-25.28	-7.75	-5.22	1.44	-.76	-5.44	-.39	-6.02	2.49	-1.38	-1.30	t (2-3)
	Sig	**0.00**	**0.00**	**0.00**	**0.150**	**0.449**	**0.00**	**0.695**	**0.00**	**0.01**	**0.169**	**NS 0.21**	**Sig**
3	Mean	8.50	134.07	28.68	148.13	95.67	131.88	4.14	5.43	1.96	.98	0.65	Mean
n	SD	0.21	6.79	6.15	15.82	14.54	12.10	.34	.47	.38	.08	1.36	SD
118	t (3-4)	-25.00	-5.39	-3.23	.68	-.38	-3.80	-.29	-4.13	1.78	-.94	-.68	t (3-4)
	Sig	**0.00**	**0.00**	**0.00**	**0.497**	**0.707**	**0.00**	**0.73**	**0.00**	**0.077**	**0.348**	**0.499**	**Sig**
4	Mean	9.50	138.17	31.36	146.83	96.34	137.01	4.15	5.66	1.88	.99	0.66	Mean
n	SD	0.40	6.06	7.44	16.15	14.85	10.69	.34	.47	.38	.07	.13	SD
171	t (4-5)	-22.95	-5.56	-2.71	.72	-.45	-4.18	-.03	-4.07	1.17	-.91	-.61	t (4-5)
	Sig	**0.00**	**0.00**	**0.00**	**0.473**	**0.654**	**0.00**	**0.976**	**0.00**	**0.242**	**0.365**	**0.541**	**Sig**
5	Mean	10.50	142.78	34.13	145.40	97.12	142.64	4.15	5.90	1.82	1.00	0.67	Mean
n	SD	0.17	7.10	8.78	14.00	10.88	9.95	.30	.44	.41	.06	.10	SD
93	t (5-6)	-22.57	-6.90	-4.06	-2.85	-2.58	-6.62	4.45	-2.86	4.09	-2.48	-.42	t (5-6)
	Sig	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.677**	**Sig**
6	Mean	11.50	149.40	39.08	150.71	101.54	152.79	3.99	6.07	1.62	1.02	0.67	Mean
n	SD	0.40	6.92	8.99	13.32	13.59	12.06	.25	.41	.33	.07	.12	SD
125	t (6-7)	-20.65	-4.56	-2.62	-2.43	-2.61	-5.07	3.87	-1.93	2.23	-2.65	-.77	t (6-7)
	Sig	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**	**0.055**	**0.02**	**0.00**	**0.433**	**Sig**
7	Mean	12.50	154.38	42.44	155.63	106.85	161.88	3.84	6.18	1.52	1.05	0.69	Mean
n	SD	0.21	8.52	8.73	15.09	14.88	12.98	.29	.36	.31	.06	.12	SD
78	t (7-8)	-19.68	-6.77	-5.37	-1.88	2.31	-3.37	.07	-4.01	4.13	1.84	2.62	t (7-8)
	Sig	**0.00**	**0.00**	**0.00**	**0.062**	**0.02**	**0.00**	**0.947**	**0.00**	**0.00**	**0.068**	**0.01**	**Sig**
8	Mean	13.50	164.02	50.98	160.30	101.92	168.78	3.84	6.45	1.33	1.03	0.65	Mean
n	SD	0.41	9.90	11.59	17.18	13.14	13.74	.24	.50	.29	.07	.12	SD
95	t (8-9)	-20.04	-3.57	-3.74	1.97	.68	-3.31	-2.35	-5.55	2.61	-.75	-.35	t (8-9)
	Sig	**0.00**	**0.00**	**0.00**	**0.05**	**0.496**	**0.00**	**0.02**	**0.00**	**0.01**	**0.454**	**0.723**	**Sig**
9	Mean	14.51	169.15	57.09	155.53	100.59	175.22	3.93	6.86	1.23	1.04	0.65	Mean
n	SD	0.16	8.41	8.97	13.29	11.85	10.79	.26	.45	.17	.07	.10	SD
74	t (9-10)	-18.44	-7.32	-5.75	.75	-.07	-3.72	-.65	-4.37	4.39	1.23	-.62	t (9-10)
	Sig	**0.00**	**0.00**	**0.00**	**0.452**	**0.943**	**0.00**	**0.514**	**0.00**	**0.00**	**0.219**	**0.537**	**Sig**
10	Mean	15.51	176.49	64.31	154.03	100.71	181.28	3.95	7.13	1.13	1.03	0.66	Mean
n	SD	0.45	6.64	9.06	14.71	12.51	12.10	.27	.43	.16	.06	.11	SD
172	t (10-11)	-12.80	-2.07	-3.00	1.39	.60	-1.14	-1.62	-3.21	1.67	-.02	-.46	t (10-11)
	Sig	**0.00**	**0.04**	**0.00**	**0.165**	**0. 551**	**0.254**	**0.107**	**0.00**	**0.096**	**0.980**	**0.648**	**Sig**
11	Mean	16.50	178.98	69.37	150.16	99.32	183.85	4.04	7.38	1.08	1.03	0.67	Mean
n	SD	0.11	5.52	9.23	16.25	12.95	12.10	.29	.30	.14	.06	.11	SD
35	t (11-12)	-12.54	-1.14	-.85	-1.11	.06	-.85	.88	.11	.90	-.26	.73	t (11-12)
	Sig	**0.00**	**0.025**	**0.395**	**0.270**	**0.955**	**0.395**	**0.380**	**0.913**	**0.369**	**0.793**	**0.468**	**Sig**
12	Mean	17.40	180.26	70.84	153.22	99.18	185.65	3.99	7.37	1.06	1.03	.65	Mean
n = 172	**SD**	0.42	6.16	9.29	14.64	13.37	11.23	.28	.41	.14	.06	.11	**SD**

Table 2: Statistical characteristics of Age, somatic and kinematic parameters of the maximal velocity sprinting stride over 10m after a 15m flying start and significance of difference between the variables - Girls

Group	Statistic	Decimal Age	Body Height (cm)	Body Weight (kg)	Support Time (ms)	Flight Time (ms)	Stride Length (cm)	Stride Frequency (Strides/sec)	Velocity (m/sec)	Relative Velocity (m.s^{-1})	Relative Stride Length (cm)	Flig/Support (sec)	Statistic
1	Mean	6.50	121.00	21.74	157.28	102.89	118.51	3.88	4.58	2.13	.98	.66	Mean
n	SD	0.17	3.77	2.67	13.89	14.37	8.66	.31	.38	.30	.06	.11	SD
46	t (1-2)	-17.07	-6.37	-3.77	.94	-1.32	-4.35	.32	-3.59	1.54	-1.29	-1.71	t (1-2)
	Sig	**0.00**	**0.00**	**0.00**	**0, 347**	**0.188**	**0.00**	**0.751**	**0.00**	**0.125**	**0.198**	**0.089**	**Sig**
2	Mean	7.51	126.50	23.94	154.96	106.51	125.73	3.87	4.83	2.05	.99	.6937	Mean
n	SD	0.39	5.41	3.63	14.59	16.56	10.05	.32	.43	.30	.07	.13	SD
134	t (2-3)	-23.55	-10.24	-7.05	-.93	-1.16	-6.88	1.47	-4.59	4.23	-1.57	-.43	t (2-3)
	Sig	**0.00**	**0.00**	**0.00**	**0.351**	**0.245**	**0.00**	**0.143**	**0.00**	**0.00**	**0.118**	**0.669**	**Sig**
3	Mean	8.52	133.65	28.04	156.80	108.90	134.79	3.80	5.10	1.87	1.01	.7004	Mean
n	SD	0.21	5.15	5.29	15.50	14.22	9.90	.32	.46	.35	.08	.11	SD
101	t (3-4)	-23.55	-6.42	-4.47	1.19	-1.34	-4.28	.22	-3.67	2.82	-.87	-1.85	t (3-4)
	Sig	**0.00**	**0.00**	**0.00**	**0.234**	**0.182**	**0.00**	**0. 828**	**0.00**	**0.05**	**0.386**	**0.066**	**Sig**
4	Mean	9.50	138.48	31.60	154.56	111.41	140.94	3.79	5.32	1.75	1.02	.7269	Mean
n	SD	0.42	6.47	6.94	14.79	15.52	12.33	.31	.49	.35	.07	.12	SD
177	t (4-5)	-12.72	-3.64	-2.65	-.54	-.54	-2.49	.73	-1.72	1.56	-.64	-.36	t (4-5)
	Sig	**0.00**	**0.00**	**0.09**	**0.592**	**0.587**	**0.02**	**0.464**	**0.087**	**0.121**	**0.523**	**0.716**	**Sig**
5	Mean	10.52	143.36	35.46	156.26	113.16	147.16	3.75	5.49	1.64	1.03	.7361	Mean
n	SD	0.12	7.41	8.61	19.88	17.59	11.85	.32	.53	.41	.07	.15	SD
28	t (5-6)	-11.15	-4.83	-2.76	-1.69	-.40	-3.94	1.96	-2.25	2.32	-.84	.78	t (5-6)
	Sig	**0.00**	**0.00**	**0.00**	**0.093**	**0.693**	**0.00**	**0.051**	**0.03**	**0.03**	**0.402**	**0.437**	**Sig**
6	Mean	11.52	151.48	40.76	161.86	114.42	157.49	3.64	5.72	1.47	1.04	.7153	Mean
n	SD	0.47	8.31	9.47	15.37	15.03	12.92	.25	.48	.33	.08	.13	SD
153	t (6-7)	-11.44	-4.20	-2.97	-1.15	-1.07	-3.71	1.56	-2.17	2.54	-.90	-.07	t (6-7)
	Sig	**0.00**	**0.00**	**0.00**	**0.250**	**0.286**	**0.00**	**0.120**	**0.03**	**0.02**	**0.370**	**0.941**	**Sig**
7	Mean	12.50	158.19	46.10	165.39	117.56	166.77	3.57	5.92	1.31	1.05	.7171	Mean
n	SD	0.12	7.03	7.07	16.41	14.24	11.53	.29	.46	.23	.06	.11	SD
31	t (7-8)	-10.91	-2.60	-2.07	-.27	1.70	.12	-.93	-.85	1.41	1.82	1.62	t (7-8)
	Sig	**0.00**	**0.01**	**0.04**	**0.788**	**0.091**	**0.908**	**0.357**	**0.395**	**0.160**	**0.071**	**0.107**	**Sig**
8	Mean	13.51	161.84	49.66	166.27	112.30	166.49	3.62	6.01	1.25	1.03	.6808	Mean
n	SD	0.51	6.81	8.77	15.81	15.34	11.54	.29	.51	.24	.07	.11	SD
104	t (8-9)	-15.60	-4.45	-3.05	1.77	1.28	-.73	-2.08	-2.58	2.18	1.82	.12	t (8-9)
	Sig	**0.00**	**0.01**	**0.00**	**0.079**	**0,203**	**0.464**	**0.04**	**0.02**	**0.03**	**0.070**	**0.905**	**Sig**
9	Mean	14.51	166.15	53.35	162.12	109.31	167.80	3.71	6.20	1.17	1.01	.6788	Mean
n	SD	0.14	5.01	5.53	13.39	14.02	10.97	.27	.43	.15	.07	.10	SD
66	t (9-10)	-18.22	-.20	-2.05	1.61	.78	.90	-1.67	-1.00	1.27	1.11	-.32	t (9-10)
	Sig	**0.00**	**0.839**	**0.04**	**0,108**	**0,434**	**0.367**	**0.097**	**0.318**	**0.203**	**0.267**	**0.747**	**Sig**
10	Mean	15.50	166.31	55.05	159.14	107.87	166.57	3.77	6.26	1.15	1.00	.6834	Mean
n	SD	0.44	4.83	6.17	13.54	13.32	9.70	.25	.40	.14	.05	.11	SD
279	t (10-11)	-16.38	-.43	-1.44	-1.36	.54	-.10	.70	.64	1.56	.12	1.03	t (10-11)
	Sig	**0.00**	**0,666**	**0.150**	**0.176**	**0.588**	**0.919**	**0.484**	**0.522**	**0.119**	**0.903**	**0.304**	**Sig**
11	Mean	16.50	166.67	56.42	161.89	106.74	166.72	3.75	6.22	1.12	1.00	.6663	Mean
n	SD	0.12	4.83	6.94	13.02	15.89	9.88	.23	.36	.14	.06	.13	SD
52	t (11-12)	-15.19	-.91	-1.33	.05	.63	1.66	-.66	1.02	1.95	2.25	.63	t (11-12)
	Sig	**0.00**	**0.365**	**0.184**	**0.958**	**0.528**	**0.098**	**0.512**	**0.310**	**0.052**	**.02**	**0.527**	**Sig**
12	Mean	17.47	167.41	57.68	161.79	105.18	163.90	3.77	6.15	1.08	.98	.65	Mean
n=197	SD	0.46	5.33	5.76	12.14	15.88	11.14	.25	.42	.13	.06	.11	SD

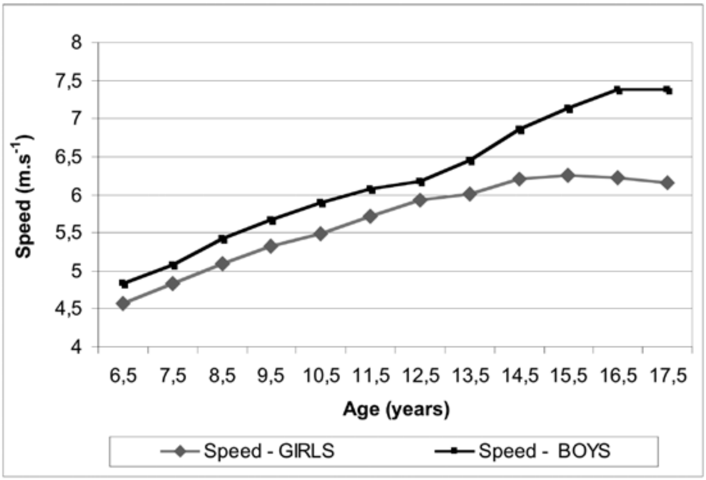

Figure 1: Average maximum sprinting velocity (over 10m after 15m flying start)

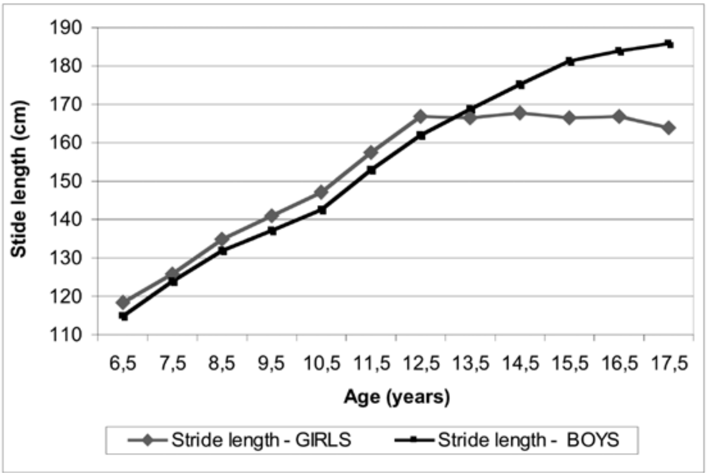

Figure 2: Average stride length at maximum sprinting velocity (over 10m after 15m flying start)

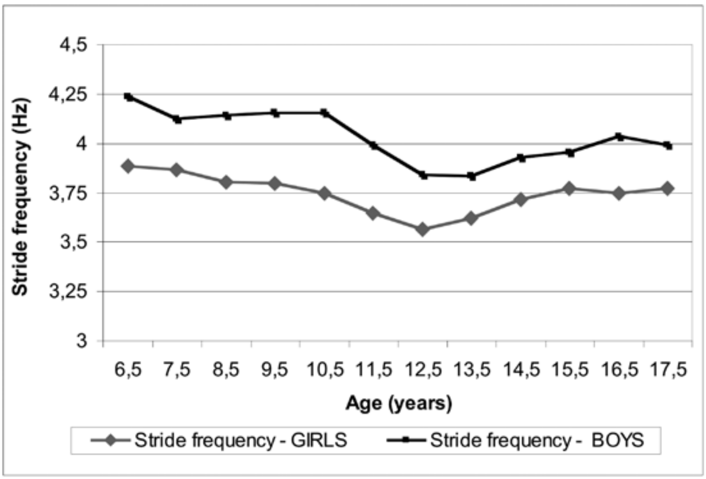

Figure 3: Average stride frequency at maximum sprinting velocity (over 10m after 15m flying start)

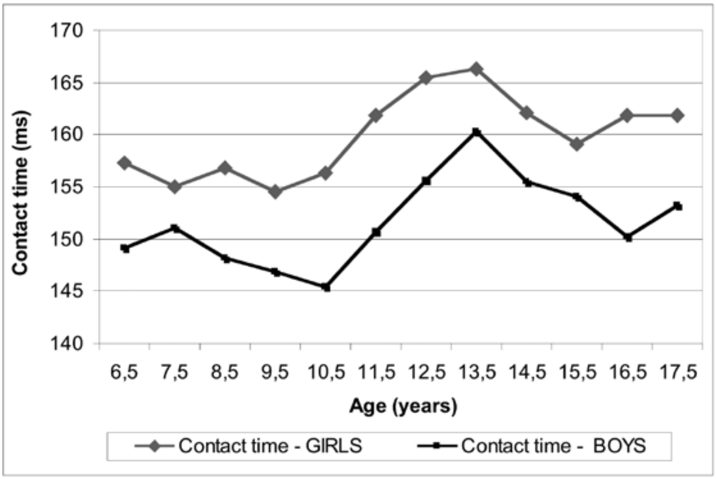

Figure 4: Average support time at maximum sprinting velocity (over 10m after 15m flying start)

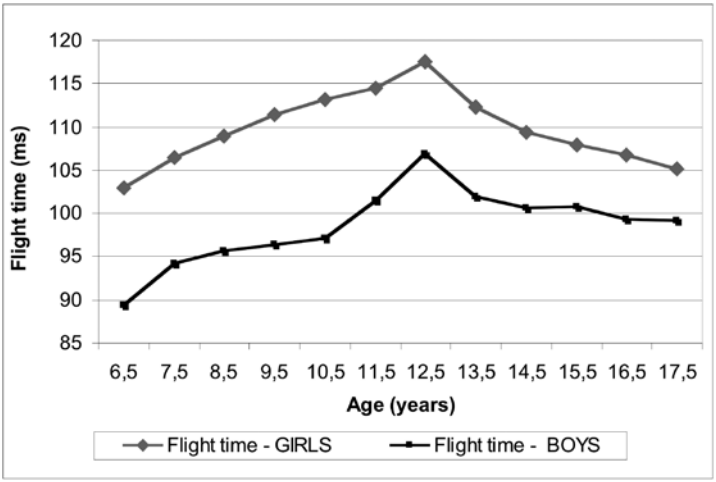

Figure 5: Average flight time at maximum sprinting velocity (over 10m after 15m flying start)

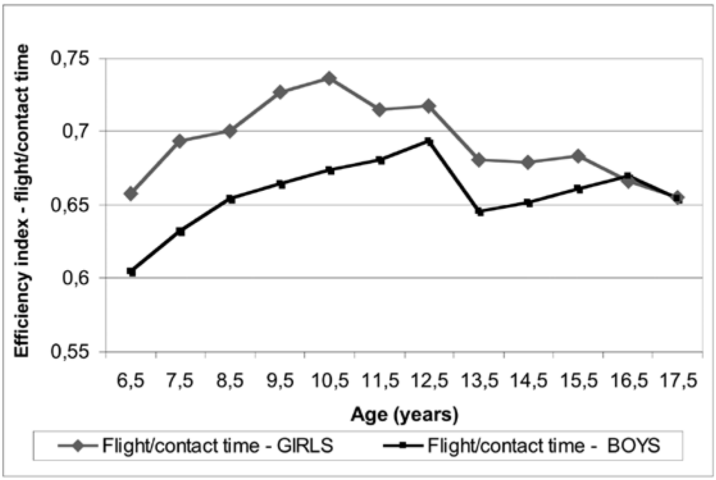

Figure 6: Efficiency index - defined by duration of the support phase and the running phase ratio – at maximum sprinting velocity (over 10m after 15m flying start)

tive velocity, relative frequency and efficiency index (boys). The results show that, for both sexes, the structure of the sprint stride changes drastically in connection to the stride length and frequency, the ratio between the support and the flight phases and the vertical force on the surface. The correlation coefficients show that the duration of the support phase, the relative stride frequency and the vertical force on the surface are good indicators of the sprinting potential of young runners.

The results of our research can be used as background for assessment of talent for sprinting. An individual can be considered talented if he or she achieves parameters of two standard deviations above mean values in indicators such as stride frequency, duration of the support phase and running velocity. It may contribute to a better understanding of the factors responsible for sprint performance in the population of athletes who are not top-level sprinters, i.e. they may be useful to PE teachers, coaches who work with novice athletes and physical conditioning coaches who work in other sports than athletics, to get a more thorough insight into the sprinting efficiency mechanisms.

Discussion

Stride frequency shows as a very stable parameter. Significant changes are only seen during the pre-pubescent period and these can be explained by deterioration of coordination, which is a result of increase in body height and weight. Moreover, ĆOH, JOŠT, KAMPMILLER & ŠTUHEC (2000) found that the development of maximal velocity is not constant, but has certain oscillations, particularly in the adolescence period, when morphological and motor characteristics of youth change. Due to acceleration of longitudinal parameters, stride frequency and stride length change; stride length increases and the stride frequency decreases significantly. Stride frequency does not change only as a result of morphological changes, but also due to disruption of proprioreceptive mechanisms for movement control.

The biggest differences in the development of maximal velocity in both genders occur between the ages of 12 and 14. We found that this coincides with a rapid reduction of the duration of the support phase in boys after the age of 12. This finding is in contradiction to BRAĆIĆ et al. (2009), who determined that the improved velocity in boys is mainly due to development of strength. However others (MERO et al., 1986 and 1992) consider support phase duration as one of the main criteria for selecting young sprinters.

Our results are comparable to earlier research by KAMPMILLER & KOŠTIAL (1986) - which was carried out with smaller samples and modified methods at school stadiums, where it was not possible to achieve a high level of standard conditions of measurement - but are influenced by the new methods used. For example, the support phase duration is 0.02 sec longer than measured in the previous study. Our findings are likewise comparable with the values of the parameters of the support phase found by ĆOH et al. (1994), who also used the Lokomometer and identified the most important kinematic-dynamic parameters, their developmental trend and their influence on efficiency in maximal running velocity for sprinters of both sexes from eleven to eighteen years of age.

We also determined that stride length and stride frequency are negatively correlated in maximal velocity running, which is the result of a positive correlation between skeleton dimensionality and stride length, on the one hand, and of a negative correlation between skeleton dimensionality and stride frequency, on the other. As far as we know, research has demonstrated integrally the mechanism of mutual relationships between subcutaneous fatty tissue, skeleton dimensionality, explosive power and kinematic parameters BABIĆ & DIZDAR (2010).

Table 3: Correlation coefficients and their significances of Age, somatic and kinematic parameters of the maximal velocity sprinting stride over10m after a 15m flying start

p<0.01**
p<0.05*

BOYS (above diagonal) / GIRLS (below diagonal)

	Decimal Age	Body Height	Body Weight	Support Time	Flight Time	Stride Length	Stride Frequency	Velocity	Relative Velocity	Relative Stride Frequency	Flight/Support	
Decimal Age	1	.937**	.889**	.141**	.150**	.885**	-.238**	.878**	-.783**	.304**	.036	Decimal Age
Body Height	.909**	1	.934**	.248**	.174**	.911**	-.337**	.851**	-.863**	.243**	.002	Body Height
Body Weight	.882**	.924**	1	.280**	.082**	.820**	-.292**	.773**	-.916**	.157**	-.081**	Body Weight
Support Time	.153**	.257**	.264**	1	.122*	.188**	-.687**	-.159**	-.439**	.042	-.623**	Support Time
Flight Time	-.053*	.001	-.082**	.049	1	.415**	-.628**	.136**	-.096**	.653**	.840**	Flight Time
Stride Length	.749**	.839**	.732**	.171**	.315**	1	-.463**	.880**	-.716**	.617**	.214**	Stride Length
Stride Frequency	-.089**	-.203**	-.147**	-.674**	-.696**	-.370**	1	.005	.426**	-.448**	-.125**	Stride Frequency
Velocity	.736**	.755**	.681**	-.240**	-.111**	.812**	.235**	1	-.589**	.456**	.182**	Velocity
Relative Velocity	-.797**	-.863**	-.928**	-.428**	.001	-.634**	.324**	-.472**	1	.032	.158**	Relative Velocity
Relative Stride Frequency	-.082**	-.069*	-.140**	-.106**	.574**	.482**	-.347**	.278**	.229**	1	.522**	Relative Stride Frequency
Flight/ Support	-.129**	-.138**	-.211**	-.565**	.835**	.160**	-.211**	0.03	.230**	.521**	1	Flight/ Support
	Decimal Age	Body Height	Body Weight	Support Time	Flight Time	Stride Length	Stride Frequency	Velocity	Relative Velocity	Relative Stride Frequency	Flight/Support	

Conclusions

The results of our research on the kinematic characteristics of the running stride in the population of seven to 18 year-old youths allows us to present following conclusions:

Running velocity measured over 10m with a 15m approach (flying start) has a linear growth tendency in the male population until 13 years of age, followed by phase of even steeper increase. In the female population after 14 to 15 years of age there is observable stagnation of the running velocity. Similar age dependence was detected while assessing the length of the running stride.

A high level of ontogenetic stability and independence from age was determined in kinematic parameters (stride frequency, support phase duration, flight phase duration, and partly in the efficiency index). These indicators can be considered predictors of maximal running velocity.

Partial deterioration of the kinematic parameters occurs in pre-pubescent and pubescent period.

Practical Recommendations

Based on our findings, we suggest that coaches and others involved in talent identification evaluate children and youths for sprinting talent on the basis of stride frequency and support phase duration. If an individual achieves values in aforesaid parameters that are two or three standard deviations higher than the population averages, as determined in our research, he or she should be considered as talented and directed to an appropriate programme of training and development.

Please send all correspondence to:
Doc. Mgr. Marian Vanderka
vanderka@fsport.uniba.sk

REFERENCES

ALCARAZ, P. E.; PALAO, J. M.; ELVIRA, J. L. L. & LINTHORNE, N. P. (2008). Effects of Three Types of Resisted Sprint Training Devices on the Kinematics of Sprinting at Maximum Velocity. ***Journal of Strength & Conditioning Research,*** 22(3), 890-897.

BRAĆIĆ, M.; TOMAŽIN, K. & ĆOH, M. (2009). Dejavniki razvoja maksimalne hitrosti pri mladih atletih in atletinjah starih od 7 do 14 let [Factors of development of maximal speed in young athletes of both genders, aged 7 to 14 years. In Slovenian]. In: Ćoh, M. (Ed.), Sodobni diagnostićni postopki v treningu atletov (pp.155-163). Ljubljana: Fakulteta za šport, Inštitut za kineziologijo.

BABIĆ, V. & DIZDAR, D. (2010). Indicators of maximal running speed. In: Abstracts Book of ***15th annual Congress of the European College of Sport Science, Antalya 23.-26.06.2010***, ISBN: 978-605-61427-0-3, (p. 598) ECSS - Antalya 2010.

BOGDANOV, S.N. (1974). Kakim byt sprinterom? [How to become a sprinter?]. ***Legkaja Atletika,*** [***Athletics***], 20 (4), 9-10.

ĆOH, M.; BABIĆ, V. & MAĆKAŁA, K. (2010). Biomechanical, Neuro-muscular and Methodical Aspects of Running Speed Development. ***Journal of Human Kinetic, Section III – Sport, Physical Education & Recreation***, 26, 73-81.

ĆOH, M.; JOŠT, B.; KAMPMILLER, T. & ŠTUHEC, S. (2000). Kinematic and dynamic structure of sprinting stride. In: M. Ćoh and B. Jošt (Eds.), Biomechanical characteristics of technique in certain chosen sports (pp. 169-176). Ljubljana: Faculty of Sport, Institute of Kinesiology.

ĆOH, M.; ŠKOF, B.; KUGOVNIK, O. & DOLENEC, A. (1994). Kinematic-Dynamic Model of Maximal Speed of Young Sprinters. In: Barabás, A. & Fábián, G. (Eds.), ***Proceedings of 12th International Symposium on Biomechanics in Sports, Siofok, 2.-6.7.1994.*** (pp. 343-346). Budapest: Hungarian University of Physical Education.

DONATI, A. (1996). Development of stride length and stride frequency in sprint performances. ***New Studies in Athletics***, 34 (1), 3-8.

KAMPMILLER, T. & KOŠTIAL, J. (1986). Štruktúra a rozvoj rýchlostných schopností v atletických šprintoch mládeže [Structure and development of speed capabilities in youth athletic sprints]. Praha: Sportpropag 1986.

KORNELJUK, A. & MARAKUŠIN, I. (1977). Problemy sprintera. [The problems of sprinters]. Legkaja Atletika, , [Athletics], 23(8), 12-14.

MACKALA, K. (2007). Optimisation of performance through kinematic analysis of the different phases of the 100 meters. IAAF 2007, 22 (2), 7-16.

MERO, A.; KOMI, P.V. & GREGOR, R.J. (1992). Biomechanics of sprinting running. Sport medicine, 13(6), 376-392.

MERO, A.; LUHTANEN, P. & KOMI, P.V. (1986). Segmental contribution to velocity of CM during contact at different speeds in male and female sprinters. Journal of Human Movement Studies, 12, 215-235.

SEAGRAVE, L.; MOUCHBAHANI, R., & O`DONNEL, K. (2009). Neuro-Biomechanics of Maximum Velocity Sprinting. New Studies in Athletics, 24(1), 19-29.

ŠELINGER, P.; KAMPMILLER, T.; SELINGEROVA, M. & LACZO, E. (1994). Measurement of kinematic parameters of running. In: Barabás, A. & Fábián, G. (Eds.), Proceedings of 12th International Symposium on Biomechanics in Sports, Siofok, 2.-6.7.1994. (pp. 340-342). Budapest: Hungarian University of Physical Education.

SIRIS, P.Z.; GAJDARSKA, P.M. & RAĆEV, K. (1983). Otbor i prognozirovanie sposobnostej v legkoj atletike [Selection and prognosis of abilities in athletics]. Moskva: FIS 1983.

TABAĆNIK, B. (1979). Kak najti sprintera [How to find the sprinter]. Legkaja Atletika [Athletics], 25(3), 12-13.

TJUPA, V.V.; ALESHINSKY S.J.; KAIMIN, M.A. & PRIMAKOV, J.N. (1978). O mechanizme vzaimodejstvija sprintera s oporoj. [About the mechanism of interaction with the support phase of a sprinter). Teor. Prakt. Fiz. Kult. [Theory and praxis of physical culture], 41 (9), 9-12.