KINEMATIC-DYNAMIC MODEL OF MAXIMAL SPEED OF YOUNG SPRINTERS

MILAN COH, BRANKO SKOF, OTMAR KUGOVNIK, ALES DOLENEC

UNIVERSITY OF LJUBLJANA, FACULTY OF SPORT, LJUBLJANA, SLOVENIA

INTRODUCTION

The purpose of this study was to find the **kinematic-dynamic** characteristics of sprint in conditions of maximal speed for selected young sprinters and on the basis of these characteristics form such a **kinematic-dynamic** model, that could be used in the training process as a criterion for selection for sprint. We wish therefore to **find** the importance of the individual parameters and their dynamics of change in those age periods, which are of key importance for the development of results in sprint. At the same time this enables greater reliability in the choice of proper training means that will make possible a high level of sports efficiency in the long-term training **process.**

RESEARCH AIMS

1. Identify the **kinematic-dynamic** parameters of maximal sprinting speed.
2. Ascertain the level of correlation between the individual **kinematic-dynamic** parameters with maximal sprinting speed.
3. Construct a **kinematic-dynamic** model of maximal sprinting speed, one that could be used as a criterion of initial selection for sprint.

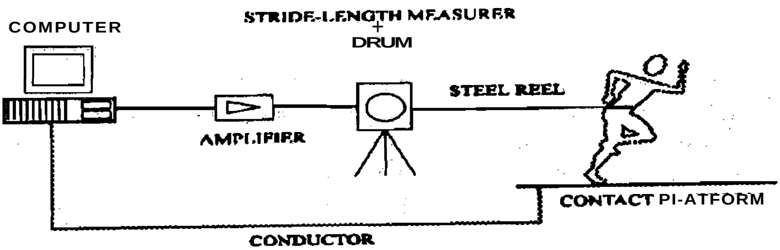
METHODS

Subject sample

The subject sample consisted of 27 young male and 35 young female sprinters, members of six slovene track and field clubs.

Measurement methodology

The project for measuring parameters of maximal sprinting speed emerged from co-operation between the Institute for Kinesiology of the Faculty of Sport in Ljubljana and the Faculty of Physical Education and Sport **(Fakulta** telesnej **vychovy** a sportu) in Bratislava. The primary instrument used to register **kinematic** variables was the LOCOMOMETER **(pic. 1),** constructed by **T.Kampmiller, E.Laczo, R.Holcek** and **P.Selinger.**



Picture 1: Locomometer

RESULTS AND DISCUSSION

Table 1: Kinematic-dynamic parameters of maximal speed for male and female sprinters of different ages (X: mean value. SD: standard deviation).

Sprinters	MALE					FE MALE				
Age	11-14		15-18			11-14		15-18		
Parameters	$\bar{X}$	SD	$\bar{X}$	SD		$\bar{X}$	SD	$\bar{X}$	SD	
Body height	162.7	12.6	174.8	4.1	**	159.3	9.6	166.7	5.8	**
Leg length	93.1	8.9	100.3	2.8	*	92.5	5.1	95.8	3.4	*
Body weight	49.7	12.5	66.4	6.6	**	46.2	8.3	52.9	5.1	*
Duration of contact	128	13.3	107	7.5	**	123	7.3	118	12.8	
Duration of flight	117	15.6	127	9.3		128	12.4	128	12.4	
Stride frequency	4.1	0.2	4.3	0.2		4.00	0.2	4.08	0.2	
Stride length	179	21.5	205	13.2	**	181	15.1	188	9.2	
Speed	7.52	0.7	8.80	0.6	**	7.23	0.4	7.65	0.5	*
Activity	0.93	0.1	1.20	0.1	**	1.04	0.2	1.09	0.2	
Relative stride length 1	1.10	0.0	1.18	0.0	**	1.14	0.1	1.12	0.1	
Relative stride length 2	1.92	0.1	2.06	0.1	**	1.95	0.1	1.96	0.1	
Relative frequency	6.64	5.8	7.50	2.9	**	6.34	3.8	6.78	4.3	*
Vertical pressure	1285	35.6	1853	9.8	**	1236	24.3	1436	14.9	*
Rel. vertical pressure	15.88	16.1	18.11	10.5	**	16.97	11.0	17.33	16.9	

**$P<0.01$ *$P<0.05$

The two age-groups differ most in the following parameters: absolute and relative vertical pressure, duration of contact, stride length and relative stride frequency. The named parameters have a common base in **neuro-muscular** efficiency, **which** manifests itself mostly in the force of push-off. This can be seen above all from the changed relative proportions of the duration of the contact and flight phases.

Differences in maximal speed between female sprinters are mostly due to differences in morphologic measures and less a consequence of differences in the **kinematic-**dynamic parameters, except vertical pressure and relative frequency.

For male sprinters **(11-14** years of age) the contact phase is longer than the flight phase, for female sprinters of the same age category this relation is just the opposite. The tendency for further development is toward shortening the contact phases and lengthening the flight phases, both males and females. This is most evident for male sprinters from **15** to 18 years of age. The proportion of the contact phase in the duration of the running stride is **52%** for the **11-14** year old male sprinters and only **46%** for the **15-18** year group. With female sprinters no significant changes were noted in the duration of the contact phase. Alongside quantitative changes, also structural - or rather the relation between the contact and flight phases - occur with young sprinters. The process of training young sprinters should be oriented precisely into changing the quality of the sprinting stride and approaching the modality of that of top sprinters. where the relation contact-flight phase is **43%** against **57%** for male sprinters and **45%** against **55%** for female sprinters (according to Lopez, **1990).**

The change in the quality of the running stride between the age categories can be seen also in parameters of frequency and especially stride length. The latter increases for male sprinters on an average by **24** cm and by **11** cm for female sprinters. The stride length is connected both with the development of motor and morphologic factors.

Stride length is without doubt connected with the force of pressure, developed by the runner on the surface. The mean value of the vertical pressure of the foot on the surface for the **11-14** year old male sprinters group is **1285** N and a massive **1853** N for the older male group, representing almost three times the mean body weight of the sprinters. The value is **1236** N for the younger female sprinters and **1436** N for the older group, being about two and a half times their mean body weight.

In light of the results in table 3, we can state that the morphological parameters: body height, leg length and body weight have a **high** positive correlation with maximal speed in the **11-14** year-old male sprinters group. **Both** longitudinal measures are also positively correlated with maximal speed in the **14-17** female sprinters group, but this correlation is less evident. The importance of the longitudinal measures, especially leg length, should be treated in context with the stride length parameter, which is in high correlation with maximal speed for all runners. Among the kinematic parameters, duration of contact, stride length, vertical pressure and relative frequency have the highest correlations.

Table 2: Correlation of kinematic-dynamic parameters with maximal sprinting speed

Sprinters	MALE				FEMALE			
Parameters	Age11-14		15-18		11-13		14-17	
Body height	**.84**	*	.06		**.50**		.56	*
Leg lenght	.78	*	.03		.36		.45	*
Body weight	.84	*	.40		.22		.33	
Time of contac	**-.41**		**-.71**	*	**-.69**	*	**-.67**	*
Time of flight	.33		.19		.09		.04	
Stride frequency	**.01**		.56	*	.63	*	.65	*
Stride length	.78	*	.61	*	.68	*	**.82**	*
Activity	**.83**	*	.56	*	.53	*	.60	*
Rel.stride length1	.49		.34		**.51**	*	.46	
Rel stride length2	**.53**	*	.49		.22		.28	
Relative frequency	.43		.52	*	.30		.32	
Verical pressure	**.89**	*	**.56**	*	.74	*	**.50**	*
Rel. vertical pressure	**.58**	*	.41		**.38**		.43	*

The parameter relative frequency, in which also body height is implied, has a pronounced informational value. This variable has a high positive correlation with absolute speed in all four age groups. Obviously, one can expect better results in sprint from those individuals, who have; beside somewhat above-average body height; also a high stride frequency.

Table 3: Kinematic-dynamic model of maximal sprinting speed

MALE SPRINTERS		Age: 11 - 14			Age: 11 - 18		
Parameters		good	very good	excellent	good	very good	excellent
20 m run flying start	s	2 74	2 52	2.32	2.38	2.24	2.11
maximal speed	m/s	7 30	7 95	8.60	8.40	8.92	9.45
Stride frequency	Hz	4.10	4.35	4.45	4.20	4.40	4.60
Rel. frequency	HzxBH	6.50	7.00	7.50	7.35	7.65	7.80
Stride length	cm	170	177	185	195	205	218
Duration of contact	ms	125	115	100	110	105	95
Activity	1	0.85	1.12	1 20	1.05	1.15	1.25
Rel stride length	1	1.00	1.10	1.15	1.15	1.18	1.24
Vertical pressure	N	1280	1530	1800	1645	1930	2050
Rel vertical pressure	N/kg	15.70	17.25	18.50	17.80	18.60	19.20

FEMALE SPRINTERS		Age: 11- 13			Age: 14 - 17		
Parameters		good	very good	excellent	good	very good	excellent
20 m run flying start	s	2.77	2.68	2.56	2.63	2.49	2 38
maximal speed	m/s	7.20	7.45	7.80	7.60	8.02	8 44
Stride frequency	Hz	4.00	4 10	4.20	4.08	4.30	4 50
Rel. frequency	HzxBH	6.00	6 50	6.80	6.45	7.05	7 43
Stride length	cm	168	170	183	178	181	190
Duration of contact	ms	120	110	100	120	108	98
Activity	1	1.04	1.10	1.15	1.06	1.15	1 21
Rel. stride length	1	1.10	1.05	1.18	1.12	1.17	1 19
Vertical pressure	N	1230	1480	1630	1420	1510	1645
Rel. vertical pressure	N/kg	15.30	17.20	18 10	15.48	17.57	18 12

On the basis of the findings of this study the following model of kinematic-dynamic parameters of maximal sprinting speed can be proposed, as a possible criterion for selection of young sprinters (table 4). The model is based on a three-level assessment scale of the kinematic-dynamic parameters. Each individual's result can therefore be assessed as "good", "very good" or "excellent". This scale was constructed on the basis of centile classes of the individual parameters. Only those individuals, whose results attain the mark "excellent" and to some degree also "very good" on the assessment scale, show true high sprinting potential.

CONCLUSIONS

Significant differences exist between male and female sprinters of different age groups in maximal speed, which are the consequence of morphological development and the transformation of kinematic and dynamic parameters. The structure of the sprint stride changes for young sprinters of both sexes, as a consequence of a greater stride length, frequency, the relative proportions of the contact and flight phases and greater vertical pressure on the surface. Anthropometric measures, especially the longitudinal ones, have a varied influence on maximal speed, depending on the age and gender of the sprinters. Inspection of the correlation coefficients shows that duration of contact is one of the most predictive indicators of the sprinting potential of young runners. This parameter has a high correlation with both the absolute and the relative pressure of the runner on the surface. These ties bear witness that better sprinters develop greater pressure on the surface in a shorter time, causing thereby also longer strides. Key mechanisms for the development of maximal sprinting speed are the efficiency of the push-off action in connection with an efficient sprinting technique.

REFERENCES

Bosco C., C, Vittori: Biomechanical Characteristics of Sprint Running During Maximal and Supra maximal Speed. New Studies in Athletics, 18611, str. 36-42.

Brüggemann P., V. Lopez: Time analysis of the sprint events. New Studies in Athletics. Supplement, 1990,11-66.

Kampmiller T., J. Kostial, J. Sedlacek, E. Laczlo, P. Selinger, R. Holcek: Razvoj specialnych schopnosti supramaximalnou rychlostlu. Telesna vychova & sport, 199112. str. 4-7.