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THE STRUCTURE OF RUNNING KINEMATIC PARAMETERS RELATED TO DIFFERENT QUALITY GROUPS OF BOYS AGED 10-12

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Original scientific paper

Abstract
Aim of the study was to determine the structure of running kinematic parameters of boys aged 10-12 that are grouped according to the results value of the 50 meters athletic sprint. Multivariate analysis of variance was used to determine differences between the formed quality groups of boys in treated variables of running kinematic parameters. Univariate F-tests indicated that the three formed quality groups of boys differ significantly in the kinematic parameters of frequency and stride length, and achieved maximum speed of running. Statistically significant difference between formed quality groups of boys was not detected in the kinematic parameters of contact and flight duration. Differences in the structure of running kinematic parameters for the formed quality groups of boys are graphically presented in the Z-5 values. Results of this study have determined that the frequency and stride length and level of achieved maximum running speed are variables that can better examine differences in the structure of running kinematic parameters of boys at the age 10-12, as opposed to the duration of contact and flight. Presented structure of running kinematic parameters can help in forming models for identification and selection of talented boys for athletic sprint.

Keywords: **Athletic sprint, running kinematic parameters, frequency and stride length, Z-5 values.**

Introduction

The basic technique of running is very simple and natural as opposed to complex technical structure of athletic sprint. Running is an inherent form of movement, whose effectiveness from the aspect of running speed is individually determined and depends on variety of hereditary functions (Babić, 2005). Biological development of running speed is not constant. This development has certain oscillation primarily during adolescence period. In the ontogenetic development of children, the term "natural biological development of speed", is used, which depends on level of development of bio-motor potential, morphological characteristics and form of motor stereotype of movement (Bračič, Tomažin and Čoh, 2009).
The effectiveness of the technique depends on changing components of kinematic parameters related to running stride, which include frequency and stride length and duration of contact and flight (Mero, Komi i Gregor, 1992; Donati, 1995; Čoh, Mihajlovič, Praprotnik, 2001; Čoh, Milanović, Kampmiller, 2001). Numerous studies of running kinematic parameters as well as studies which include different aspects of biological development of running speed, confirm that stride frequency depends on function of the central nervous system, inter-muscular and intramuscular coordination, and central and peripheral nervous fatigue. Stride length depends on morphological characteristics, impulse force at take-off, duration of contact phase, dynamic flexibility in the hips, distances of take-off and contact (Čoh, Bračič and Smajlović, 2010).
A number of studies tried to established different models of identification and selection for athletic sprint (Balsevich, 1996; Zeličenok, 1998). Tomažin, Čoh and Škof (1999) have set a reduced model which measure success, for the athletic sprint, by analyzing the morphological and motor characteristics of adolescents. They concluded that the most appropriate period for the initial selection and introduction to athletics sprint disciplines is the age between 11 and 12. They also emphasized the importance of knowing the substantial characteristics, which in this age period have the greatest impact to explain performance level of result.

Two main objectives of this research were:
- Determination of differences in the structure of running kinematic parameters of boys aged 10-12, who were divided into three quality groups formed according to the result value in 50 m athletic sprint;

- Important information for future modeling of identification and selection of talented boys for athletics sprinting, in terms of relevant kinematic parameters related to running in the age 10-12.

Methods

The study was conducted on a sample of eighty one (81) subjects – pupils of the fourth grade of elementary school, aged 10-12 (body height ABH = 145,3 ± 6,6 cm, body mass ABM = 39,7 ± 8,8 kg). The sample was divided into three quality groups according to criterion variable – the 50m running result (KT50m). Sample of variables for estimating running kinematic parameters included a set of six variables: maximum running speed (KVMAX), 20m running time from flying start (KTLS20m), stride frequency (KFK), stride length (KDK), duration of contact (KTK) and duration of the flight (KTL). Kinematic parameters were registered on tensiometric carpet (Ergo Tester Bosco), while the result and maximum speed of running at 50 m were registered with a system of infrared photocells (Brower). Photocells were placed at every 5 meters from the start to the finish line.
The frequency and stride length, duration of the contact and the flight during running strides were registered in the 20 m – 40 m section for the entire distance (fig. 1).

Figure 1 - Measurement of running kinematic parameters at tensiometric carpet in the 20 m – 40 m section of the entire distance (KT50m)

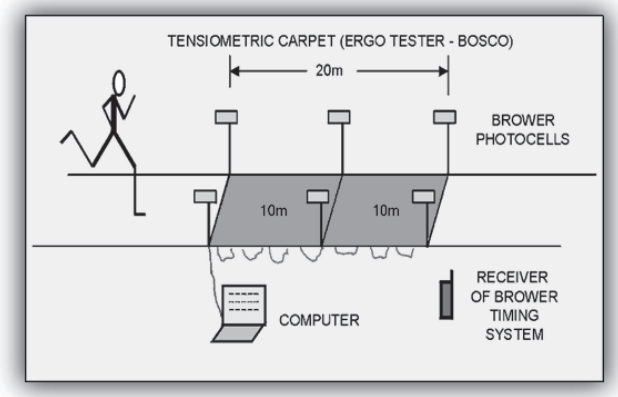


Table 2 – Average values of running kinematic parameters of formed quality groups of boys

Variable	*Maximum running speed (KVMAX) – m/s*		*20m running time from flying start (KTLS20m) – s*		*Stride frequency (KFK) – strides per sec.*	
Group	AS	SD	AS	SD	AS	SD
1 – Above-averige	6,67	,197	3,11	,061	4,17	,150
2 – Averige	6,02	,253	3,47	,143	3,95	,245
3 – Below-averige	5,40	,215	3,90	,126	3,84	,281
Entire sample	6,02	,433	3,48	,262	3,96	,256
Variable	*Stride length (KDK) – cm*		*Duration of contact (KTK) – s*		*Duration of flight (KTL) – s*	
Group	AS	SD	AS	SD	AS	SD
1 – Above-averige	153,38	6,035	,135	,005	,106	,008
2 – Averige	146,05	10,309	,166	,110	,103	,013
3 – Below-averige	135,38	8,471	,167	,014	,096	,013
Entire sample	145,51	10,719	,161	,092	,102	,013

The sample was divided according to the results value of 50 meters running in three quality groups (1 – Above-average, 2 – Average, 3 – Below-average group). Classification of the quality groups was based on the curve distribution of results and the standard deviation (SD): subjects above the value +1 SD were classified as the group with above-average success results in running (1); subjects within ±1 SD were classified as the group with an average success results value in running (2); subjects below the value –1 SD were classified as the group with below-average success results in running (3). Through analyses of variance (ANOVA), differences between the formed quality groups in the variables of running kinematic parameters were investigated. Through univariate F-tests, variables of kinematic parameters by which formed quality group of boys differ significantly were determined. Based on Z5-values of all variables, the chart was formed which presents the structure of running kinematic parameters related to different quality groups of boys.

Results

Table 1 presents the average values (AS) of the 50 meters running results for three formed quality groups of boys. The first formed above-average group consisted of 13 boys where the average value of the results amounts to 8,95 seconds. The second formed average group consisted of 55 boys where the average value of the results was 9,87 seconds. The third formed below-average group consisted of 13 boys and reached an average value of 11,02 seconds.

Table 1 – Average values of the 50m running results for different quality groups of boys

	50m running result (KT50m) – s		
Group	AS	SD	N
1 – Above-averige	8,95	,210	13
2 – Averige	9,87	,337	55
3 – Below-averige	11,02	,282	13
Entire sample	9,91	,666	81

Table 2 presents the overview of average values level for running kinematic parameters in three formed quality groups of boys.

According to all multivariate tests (Pillais, Hotelings, Wilks, Roys), it can be concluded that there is statistical significance in taxonomic classification for selected quality groups (Table 3).

Table 3 – Multivariate tests of significance for classification to quality groups according to the criterion variable (KT50m)

Test name	Value	Approx. F	Hypoth. DF	Error DF	Sig. Of F
Pillais	,93535	9,16196	14,00	146,00	,000
Hotellings	4,12811	20,93542	14,00	142,00	,000
Wilks	,17373	14,39135	14,00	144,00	,000
Roys	,79879				

Variables of running kinematic parameters with statistical significance for classification into three quality groups of boys were determined through univariate F-tests (Table 4).

Table 4 – Univariate F-tests: Variables of kinematic parameters of running by which formed quality groups of boys differ significantly

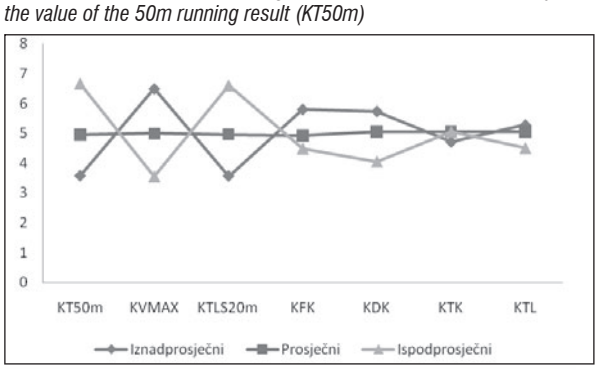
Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
KT50m	27,88737	7,60567	13,94368	, 09751	142,99953	,000
KVMAX	10,52545	4,47730	5,26273	,05740	91,68297	,000
KTKS20m	4,13810	1,33914	2,06905	,01717	120,51432	,000
KFK	,77876	4,44619	,38938	,05700	6,83097	,002
KDK	2155,23201	7036,99021	1077,61601	90,21782	11,94460	,000
KTK	,01118	,65902	,00559	,00845	,66172	,519
KTL	,00073	,01272	,00036	,00016	2,23095	,114

For the purpose of clarity and comparability of differences between three formed quality groups of boys, all average values of variables of kinematic parameters (AS) have been converted to average Z5-values (Table 5). On the basis of the converted Z5-values of all variables, the differences were then graphically presented in the structure of running kinematic parameters (Graph 1).

Table 5 – Z5-values of running kinematic parameters of formed quality groups of boys according to the value of the 50m running result(KT50m)

Group	KT50m	KVMAX	KTLS20m	KFK	KDK	KTK	KTL
1 - Above-averige	3,571	6,491	3,562	5,801	5,734	4,706	5,276
2 - Averige	4,944	4,990	4,961	4,930	5,050	5,055	5,052
3 - Below-averige	6,667	3,550	6,604	4,494	4,055	5,060	4,505

Graph 1 – The structure of running kinematic parameters formed by the value of the 50m running result (KT50m)



Discussion

By comparing the average values (AS) of different quality groups of boys aged 10-12 it is evident that only the above-average quality group is characterized with the average value of the 50 meters running result at below 9 seconds (KT50m = 8,95 s), and the highest average achieved maximum running speed (KVMAX = 6,67 m/s). The above-average quality group of boys is characterized by the highest values of kinematic parameters – stride frequency (KFK = 4.17 strides per second) and stride length (KDK = 153 cm), which makes this group different at a

high level of statistical significance in relation to the other two formed quality groups of boys. The above-average quality group of boys is characterized by better values of contact duration (KTK = 0,135 s) and duration of flight (KTL = 0,106 s), but according to these two kinematic parameters there are no statistically significant differences between three formed quality group of boys aged 10-12.

Obtained average values of running kinematic parameters in the entire sample and three formed quality groups of boys were compared with the results of the study Bračič et al. (2009), which was conducted on a selected sample of boys aged 9-10 and 11-12 years, who were participants in athletic school. This selected sample had the following average values of running kinematic parameters: boys aged 9-10 years have reached maximum running speed of 6,06 m/s, with the stride frequency of 4,07 strides per second, stride length of 150,1 cm, and contact duration of 0,142 s; On the other hand, boys aged 11-12 years have reached maximum speed of 7,27 m/s, with a stride frequency of 4,11 strides per second, stride length of 171,9 cm, and contact duration of 0,127 s. These obtained average values of kinematic parameters in the study Bračič et al. (2009) are better than the values obtained in our study, which could primarily be due to their greater homogeneity of selected sample that actively practice in the athletic school.

It can be determined that the average value of the running kinematic parameters of above-average group of boys in this study showed similar average values as the results of the study Bračič et al. (2009), which is primarily evident in the case of stride frequency (KFK – 4,17 compared to the 4,11 strides per second). Stride frequency has value between 4 and 4,5 strides per second during adolescent development (Babić, 2005), which is also observed in the case of above-average group of boys in this study.

The observation of obtained differences between the formed quality groups of boys revealed that statistical significance at the highest level (sig. $F > 0.01$) were achieved by criterion variable the 50 m running result (KT50m) and four other variables – maximum running speed (KVMAX), 20m running time from a flying start (KTLS20m), and kinematic parameters of stride frequency (KFK) and stride length (KDK). Statistically significant differences between the formed quality groups, according to the criterion of result (KT50m) have not been established in the kinematic parameters of contact duration (KTK) and flight duration (KTL).

When inspecting the differences in the structure of running kinematic parameters between the three formed quality group (table 5 and graph 1), it is necessary to take into account the fact that during the conversion of variables in the Z5-values – the 50m running result (KT50m), 20m running time from a flying start (KTLS20m) and duration of contact (KTK) are inversely scaled values. This means that lower Z5-values in the case of these three variables represent better indicators. The average quality group of boys has achieved all Z5-values at level 5, which means that its indicators of running kinematic parameters were also on the average level of the entire sample.

The biggest differences were determined between above-average and below-average groups in the variables – 50m running result (KT50m), maximum running speed (KVMAX) and 20m running time from a flying start (KTLS20m), followed by very noticeable differences in the variables of stride length (KDK) and stride frequency (KFK).

The smallest differences in the Z5-values in the three formed quality groups were detected in the variables of contact duration (KTK) and duration of flight (KTL).

It is interesting that Z5-values in the variable duration of contact (KTK) were almost at the same level in the case of average and below-average group, and with better average Z5-value in the case of above-average quality group. On the other hand, formed Z5-value in the variable duration of contact (KTL) was almost at the same level in the case of above-average and average group, while in the case of below-average quality group a lower Z5-value was observed.

Large number of previous studies confirmed determining influence of the frequency and stride length on speed of running (Kyrolainen et al.2001; Čoh et al. 2001; Čoh et al. 2004), significant causal dependence of those kinematic parameters and the results of running in the athletics sprint, which was also confirmed by this study. Stride frequency is limited by the length of strides, which is in turn determined by the amount of force at take-off from the ground. In this research, there was no statistically significant difference in the variable duration of contact (KTK) between three formed quality groups of boys aged 10-12. Though it is important to point out that the duration of contact phase rapidly decreases after 12 years of age (Bračič et al. 2009), and that represents one of the main criteria for the selection in the athletic sprint. It is evident that an inadequate level of kinematic parameters adversely affects the result of the running. Therefore, low level of reaching maximal running speed, short stride length and low stride frequency, inferior 20m running time from a flying start, and an inadequate relation between the duration of contact time and duration of the flight can only produce poor results in the athletic sprint.

Conclusion

Based on the results of this study, it can be concluded that the above-average quality group of boys, aged 10-12, formed by the value of the 50m running result (KT50m) are characterized by the best values of running kinematic parameters, i.e. the best maximum running speed (KVMAX) and 20m running time from a flying start (KTLS20m), the highest frequency (KFK) and stride length (KDK), the minimum duration of the contact (KTK) and longer duration of the flight (KTL).

Results of this study indicate that the frequency and stride length and level of achieved maximum running speed, are the components that can better identify the differences of running kinematic parameters of boys aged 10-12, as opposed to the parameters of the duration of contact and flight.

Presented structure of running kinematic parameters of boys aged 10-12 can be used when forming a selection model for talented boys for athletic sprint. This selection model for boys talented in athletic sprinting age 10-12 should primarily take into account the kinematic parameters of stride frequency, stride length and achieved level of maximum running speed. Nevertheless the identification and selection of boys talented in athletic sprinting is complex and time consuming process therefore conclusions should not be prematurely drawn, and it is also necessary to pay close attention to the ontogenetic development of other important anthropological characteristics.

References

Babić, V. (2005). The influence of motor abilities and morphological characteristics of the sprinting.
(Doctoral dissertation). Zagreb: Faculty of Kinesiology.

Balsevich, V.K. (1996). Identification and Development of talent in sport. In: Rogozkin & Maughan (Ed.) Current Research in Sport Sciences (1-4). New York: Plenum Press.

Bračić, M., Tomažin, K., & Čoh, M. (2009). Factors of the development of maximum speed in young female athletes aged 7 to 14 years. Ljubljana: Faculty of sport, Institute of Kinesiology.

Donati, A. (1995). The development of strides length and stride frequency in sprinting. *New Studies in Athletics*, 10 (1), 51-66.

Čoh, M., Bračić, M., & Smajlović, N. (2010). Methodical aspects of maximum speed development. Sport Science, 3(2), 11-14.

Čoh, M., Bračić, M., & Smajlović, N. (2004). Caratteristiche cinematiche delle velociste durante la fase di accelerazione e la fase di massima velocita. Atletica Studi, Trimestrale di ricerca scientifica e tecnica applicata all'atletetica leggera, 2004/4, 2005/1-2. Federacione Italiana di Altetica Legera.

Čoh, M., Milanović, D., & Kampmiller, T. (2001). Morphological and kinematic characteristics of elite sprinters. *Collegium Antropologicum*, 25, 605-610.

Čoh, M., Mihajlovič, S., & Praprotnik, U. (2001). Morphological and kinematic characteristics of top sprinters.U M. Čoh (ur.) Biomehanika atletike. Ljubljana: Faculty of sport.

Kyrolainen, H., Belli, A., & Komi, P. (2001). Biomechanical factors affecting running economy. Medicine & Science in Sport & Exercise, 8, 1330-1337.

Mero, A., Komi, P.V., & Gregor R.J. (1992). Biomechanics of sprint running: A rewiew. Sports Medicine, 13, 376-392.

Likić, S. (2011). Manifestations of kinematic parameters, morphological characteristics and qualities of speed-strong boys on achieving maximal running speed and the results, success in athletics sprint. (Doctoral dissertation). Mostar: Teaching faculty University „Džemal Bijedić" u Mostaru, Department of sport and Health.

Tomažin, K., Čoh, M., & Škof, B. (1999). Reduciran potencijalni model uspešnosti mladih šprinterk v teku na 60 metrov. U: E.Hofman (ur.) Zbornik radova 4. konferencije o sportu Alpe-Jadran "Školski sport", Rovinj, 23.-26.06.1999., str. 350–353. Zagreb: Fakultet za fizičku kulturu.

Zeličenok, V. B. (1998). Kriterii otbora kak osnova komplektovanija s bornyh nacionajnyh komand po ljeghoj atletike. Moskva.

Submitted: November 27, 2013
Accepted: December 11, 2013

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