

RELATIONS BETWEEN KINEMATIC PARAMETERS OF SPRINTER'S RUNNING AND SPECIFIC MOTOR ABILITIES

(Original scientific paper)

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Abstract

Since sprinting is the quickest form of human motion, the object of this research is the structure of sprinter's running with children of an earlier school-age. This research's aim has been to determine the relations between kinematic parameters of sprinter's running and specific motor abilities with girls and boys of an earlier school-age. The sample of examinees has been made by 150 male and female pupils (70 male and 80 female pupils) belonging to the first and second grade of a primary school in Pula, Croatia. The sample of variables consists of variables which determine the kinematic parameters of sprinter's running in the phase of maximal running speed (step frequency, step length, the duration of contact with the pad and the duration of the flight phase), those which determine the 50 metres running time and those which determine the specific motor abilities (the Counter movement jump test and the Three connected jumps test). The average boys' running time on the 50 metres lap has been 10.098 s, while girls have achieved the time of 10.588 s. Regarding the maximal running speed on the 50 metres lap, boys have showed a higher frequency and lower step length as well as a shorter duration of contact between the foot and the pad and a shorter duration of the flight phase than girls. The forward stepwise regression analysis has been used to define the relations between specific motor abilities and kinematic parameters of sprinter's running. Results have showed that the boys' 50 metres running time (KT50) is highly connected to the variable of three connected jumps (MTPS), while the girls' 50 metres running time is connected to the variable jump from a static position with preparation (MCMJ).

Keywords: *girls, boys, maximal speed, jump test running time 50 m, duration of the contact, duration of flight, frequency of steps, length of the steps, stepwise regression analysis,*

INTRODUCTION

Running is a natural form of motion and is not demanding when it comes to its performance, but to be successful in running it is necessary to master a good running technique. In its basis, the running technique is simple, but the runner's individual characteristics and preparation have a significant effect on performing some components. Running is always a connection of the runner's consciousness, his or her motor ability taking part into it and the level of functional readiness of his organs and systems with the motion activity in certain outdoor conditions, etc. (Šnajder & Milanović, 1991).

Sprinter's running has been researched in different ways and in the sense of its motor performance sprinting looks like a simple biomotor activity. However, sprinting is a very demanding motor ability when it comes

to coordination and it is not so easy to master it. The sprinter's running main aim is to achieve the maximal running speed in the shortest length of time and to keep it on the lap as long as possible.

The sprinting disciplines' main aim is to run the lap in an as short time as possible, while the sprinter's running lap can be conditionally divided into four stages: the starting position or start, the starting acceleration, running on the track and entry into the finish line (finish). The running result on the lap shows the running dynamic. It depends on the time of the starting reaction (latent time), the quality of the starting acceleration (acceleration phase), the running speed and the possibility of keeping the maximal speed as long as possible with a minimal deceleration at the finish line (deceleration phase) (Babić, 2005).

During the support time the running step can be divided into *the front and rear support phase*, while during the forward transmission of the foot it can be divided into *the rear and front swing phase*.

All the phases have been assigned the following positions: *the moment of the vertical of the supporting leg* divides the phases of the front and rear support; *the moment of the vertical of the swing leg* divides the phases of the rear and front swing; *the moment of leaving the pad* divides the phases of the rear support and rear swing; *the moment of the front touch* divides the phases of the front swing and the front support.

The children's sprinter's running is different from the adults' mainly concerning the differences in motor abilities. There are also differences in morphological characteristics, physiologic and biochemical characteristics and psychological and sociological characteristics.

A lower height and length of the leg do not make possible the same step lengths in sprinter's running, while a smaller cross-section of the muscle and a lower muscular mass impede the equal development of the muscular power as with adults. Children have a different activation pattern and percentage of muscular fibres activation with the consequence of a lower manifestation of power.

The object of this research is the structure of sprinter's running with children of an earlier school-age since sprinting is the quickest form of human motion. This research's aim has been to determine the relations between kinematic parameters of sprinter's running and specific motor abilities with girls and boys of an earlier school-age.

METHODS

Sample of examinees

The sample of examinees has been made of 150 male and female pupils from the first and second form of a Pula's primary school (70 male and 80 female pupils). The average male pupils' age was 8.12 ± 0.63 , their height 133.56 ± 7.66 centimetres, and their body mass 31.42 ± 8.05 kilogrammes. The average female pupils' age was 8.08 ± 0.61 , their height 132.05 ± 6.44 centimetres, and their body mass 29.91 ± 7.25 kilogrammes.

Sample of variables

The sample of variables has been made of variables used for determining the kinematic parameters of the sprinter's running in the phase of the maximal speed (the frequency of steps, the length of steps, the duration of the contact and the flight), the 50 metres running time and the variable used to determine the specific motor abilities (the Counter movement jump test and the Three connected jumps test).

Methods of data processing

The 50 metres running has been measured on the athletic track. An electronic measuring system has been placed on the pad behind the start line. This system consists of a base and a personal computer, and there are

connections for ten pairs of photocells on it. When the examinees pass near the photocells, through a 5 millimetres ray's field, the running time on segments of the track from 5 to 50 metres is registered.

Kinematic parameters of the sprinter's running in the phase of maximal speed in the segment from the 15th to the 35th metre on a 50 metre section and the running time on a 50 metre section have been collected for the needs of this research. The kinematic parameters of the sprinter's running in the phase of maximal speed have been collected by applying the Opto jump technology which was set on the segment between the 15th and the 35th metre, on a length of 20 metres. The computer programme Sprint comes along with the Opto jump technology. It makes notes about the *speed and the running time (KT50)*, *the length of the contact (KTK)* and *of each step's flight (KTL)* and it works out the average running speed, *the average frequency of the step (KFK)* and *the length of the steps (KDK)*.

Two motor tests intended to measure the specific motor abilities, namely those showing the take-off power of the leg, have been used in this research.

The first test which measured was the *Jump from a static position with preparation or the Counter movement jump (MCMJ)*. It was performed by the examinee standing in the start position (standing on the pad with legs stretched and with arms on hips), then performing a half-squat (legs bent at an angle of 90 degrees) and in the end taking off upward. The task was performed twice without leaving the pad (15'' pause). The explosive power of a flexible character was measured by this test, while each centimetre more in a jump meant a better explosiveness of movements. The test was performed on an athletic track on which the Opto jump technology linked to a computer registering data was set.

The second test measured was the *Three connected jumps (MTPS)* where the examinee was standing on the pad in the start position with legs stretched and arms on hips, performing three connected vertical high jumps without former preparation. The aim was to achieve the highest jump in centimetres possible. The task was performed twice with a pause of 15''. The explosive power of the legs was measured by this test. The test was performed on an athletic track on which the Opto jump technology linked to a computer registering data was set.

The programme pack Statistica ver. 7.1. (StatSoft, Inc., TULSA, USA) has been used for data processing. The basic descriptive parameters based on the examinees' sex have been worked out for the variables motor abilities and kinematic parameters in maximal speed running.

The forward stepwise regression analysis has been used with both girls and boys to determine the relations between specific motor abilities and kinematic parameters in maximal speed running.

RESULTS

The following descriptive values have been worked

out for the descriptive analysis of kinematic and motor variables: *the arithmetic mean (AS), the minimal result (Min), the maximal result (Max), the standard deviation (SD), the asymmetry coefficient (Skewness), the distortion coefficient (Kurtosis) and the maximal deviation of the relative cumulative empirical frequency from the relative theoretical frequency (maxD).*

The descriptive analysis of variables has been worked out for all examinees, while the results have been showed separately for boys and girls.

The results of the Kolmogorov-Smirnovljevič test have showed that in the kinematic variables of sprinter's running all the results were regularly distributed with a possibility of conclusion errors up to 0.05. The average boys' running time on the 50 metres lap has been 10.098 s, while girls have achieved the time of 10.588 s. Regarding the maximal running speed on the 50 metres lap, boys have showed a higher frequency and lower step length as well as a shorter duration of contact between the foot and the pad and a shorter duration of the flight phase than girls.

The relations between kinematic parameters at maximal speed running and the specific motor abilities

have been determined using the forward stepwise regression analysis.

Jump from a static position with preparation or the Counter movement jump (MCMJ), Three connected jumps (MTPS), multiple correlation (R), the determination coefficient (R^2), the F-value by which the statistic significance has been tested (F), the standard prognosis error (SEE), the value of the dependent variable for the neutral values of the independent ones (Intercept), the standardized regression coefficient (β), partial correlations (r_p), correlations between dependent and independent variables (r), standard errors of standardized regression coefficients (β_e), non-standardized regression coefficients (B), standard errors of non-standardized regression coefficients (B_e), t-values by which the significance of regression coefficients has been tested (t), the level of significance (p).

The results of the boys' forward stepwise regression analysis have been shown in *table 3*. According to the results obtained, a significant connection has been determined between the predictive group of variables about the specific motor abilities and the criteria variables *50 metres running time (KT50), duration of the flight*

Table 1. Descriptive parameters for the variable boys' sprinter's running technique (N=70)

Variables	AS	Min	Max	SD	Skew.	Kurt.	maxD
KTK (<i>the duration of the contact</i>)	.154	.117	.198	.016	-.145	.159	.06
KTL (<i>the duration of the flight</i>)	.099	.060	.125	.013	-.401	.346	.07
KFK (<i>the frequency of steps</i>)	3.991	3.380	4.640	.255	.114	-.057	.06
KDK (<i>the length of steps</i>)	135.295	94.000	154.250	10.464	-.851	2.532	.08
KT50M (<i>running time</i>)	10.098	8.067	12.096	.801	.337	.541	.09

Table 2. Descriptive parameters for the variable girls' sprinter's running technique (N=80)

Variables	AS	Min	Max	SD	Skew.	Kurt.	maxD
KTK (<i>the duration of the contact</i>)	.161	.127	.203	.017	.167	-.753	.08
KTL (<i>the duration of the flight</i>)	.112	.076	.156	.015	.020	.183	.06
KFK (<i>the frequency of steps</i>)	3.697	3.100	4.550	.288	.484	.185	.07
KDK (<i>the length of steps</i>)	138.278	114.250	160.580	10.686	-.137	-.773	.08
KT50M (<i>running time</i>)	10.588	8.636	12.379	.925	.219	-.600	.06

Table 3. Results of the forward stepwise regression analysis in the manifest area between kinematic parameters of sprinter's running and boys' specific motor abilities

$R=0.33$; $R^2=0.11$; $F(1.67)=8.34$ $p<0.005$; $SEE=0.761$								
KT50 (running time 50 m)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					11.53	0.50	22.85	0.00
MTPS	-0.33	-0.33	-0.33	0.12	-0.09	0.03	-2.89	0.01
$R=0.12$; $R^2=0.01$; $F(1.67)=1.10$ $p<0.29$; $SEE=0.01$								
KTK (duration of the contact)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					0.16	0.01	15.45	0.00
MTPS	-0.13	-0.13	-0.13	0.12	0.00	0.00	-1.05	0.30
$R=0.31$; $R^2=0.10$; $F(1.67)=7.62$ $p<0.007$; $SEE=0.01$								
KTL (duration of flight)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					0.08	0.01	10.20	0.00
MCMJ	0.32	0.32	0.32	0.12	0.00	0.00	2.76	0.01
$R=0.18$; $R^2=0.03$; $F(1.67)=2.38$ $p<0.12$; $SEE=0.253$								
KFK (frequency of steps)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					4.22	0.15	27.35	0.00
MCMJ	-0.19	-0.19	-0.19	0.12	-0.01	0.01	-1.54	0.13
$R=0.42$; $R^2=0.18$; $F(2.66)=7.26$ $p<0.001$; $SEE=9.615$								
KDK (length of the steps)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					110.59	6.62	16.70	0.00
MCMJ	0.24	0.18	0.16	0.16	0.73	0.50	1.46	0.15
MTPS	0.22	0.17	0.15	0.16	0.81	0.58	1.39	0.17

(KTL) and length of step (KDK).

The criterion variable 50 metres running time (KT50) has been the first one. The obtained results have showed a statistically significant connection between the predictive group and the independent variable ($R=0.33$). The predictive group has explained 11% of the variance, while a statistically significant connection with the criterion variable has been determined for the variable three connected vertical jumps (MTPS; $r=-0.33$). The criterion variable 50 metres running time (KT50) has been inversely scaled. Thus, the variable three connected vertical jumps has had a positive effect on the criterion variable.

The third criterion variable has been the duration of flight (KTL). The connection between the predictive group of variables and the independent variable is statistically significant ($R=0.31$), while the predictive group has explained 10% of the variance. A significant connec-

tion between predictive variables and the criterion variable has been determined for the variable jump from a static position (MCMJ; $r=0.32$).

The fifth variable has been the criterion variable length of step (KDK). The connection between the predictive group and the independent variable is $R=0.42$ and is statistically significant. The predictive group has explained 18% of the variance, while the connection between the predictive variables and the criteria variable has not been determined.

The connection between the predictive group of variables with the second (duration of contact or KTK) and the fourth (frequency of steps or KFK) criterion variable is not statistically significant.

Jump from a static position with preparation or the Counter movement jump (MCMJ), Three connected jumps (MTPS), multiple correlation (R), the determination coefficient (R^2), the F-value by which the statistic

Table 4. Results of the forward stepwise regression analysis in the manifest area between kinematic parameters of sprinter's running and girls' specific motor abilities

$R=0.60$; $R^2=0.36$; $F(2.74)=20.87$ $p<0.000$; $SEE=0.749$								
KT50 (running time 50 m)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					13.29	0.43	30.90	0.00
MCMJ	-0.48	-0.37	-0.32	0.14	-0.13	0.04	-3.43	0.00
MTPS	-0.15	-0.13	-0.10	0.14	-0.04	0.04	-1.09	0.28

$R=0.44$; $R^2=0.19$; $F(1.75)=18.54$ $p<0.000$; $SEE=0.01$								
KTK (duration of the contact)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					0.20	0.01	22.81	0.00
MCMJ	-0.45	-0.45	-0.45	0.10	0.00	0.00	-4.31	0.00
KTL (duration of flight)				R=0				

$R=0.31$; $R^2=0.09$; $F(1.75)=8.05$ $p<0.005$; $SEE=0.277$								
KFK (frequency of steps)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					3.27	0.15	21.41	0.00
MCMJ	0.31	0.31	0.31	0.11	0.03	0.01	2.84	0.01

$R=0.42$; $R^2=0.18$; $F(2.66)=7.26$ $p<0.001$; $SEE=9.615$								
KDK (length of steps)	β	r_p	r	β_e	B	B_e	t(54)	p
Intercept					115.18	5.29	21.78	0.00
MCMJ	0.46	0.46	0.46	0.10	1.43	0.32	4.45	0.00

Table 5. Correlations between variables Three connected jumps (MTPS) and Jump from a static position with preparation (MCMJ).

Variables	Boys		Girls	
	MCMJ	MTPS	MCMJ	MTPS
MCMJ	1	0.72	1	0.75
MTPS	0.72	1	0.75	1

significance has been tested (F), the standard prognosis error (SEE), the value of the dependent variable for the neutral values of the independent ones (Intercept), the standardized regression coefficient (β), partial correlations (r_p), correlations between dependent and independent variables (r), standard errors of standardized regression coefficients (β_e), non-standardized regression coefficients (B), standard errors of non-standardized regression coefficients (B_e), t-values by which the signifi-

cance of regression coefficients has been tested (t), the level of significance (p).

The results of the girls' forward stepwise regression analysis have been shown in table 4. The obtained results have demonstrated a significant connection between the predictive group of variables of specific motor abilities and the criteria variables 50 metres running time (KT50), duration of contact (KTK), frequency of steps (KFK) and length of steps (KDK). The first variable

has been the criterion variable *50 metres running time* (KT50). The obtained results have showed a statistically significant connection between the predictive group and the independent variable ($R=0.60$). The predictive group has explained 36% of the variance. A statistically significant connection with the criterion variable has been found with the variable *jump from a static position with preparation* (MCMJ; $r=-0.32$). The criterion variable *50 metres running time* (KT50) has been inversely scaled which means that the variable *jump from a static position with preparation* (MCMJ) has a positive effect on the criterion variable.

The criterion variable *duration of contact* (KTK) has been the second one. The obtained results have showed that there is a statistically significant connection between the predictive group and the independent variable ($R=0.44$). The predictive group has explained 19% of the variance, while a statistically significant connection with the criterion variable has been determined for the variable *jump from a static position with preparation* (MCMJ; $r = -0.45$).

The fourth has been the criterion variable *frequency of steps* (KFK). The connection between the predictive group of variables and the independent variable is statistically significant ($R=0.31$), while the predictive group has explained 9% of the variance. A significant connection between the predictive and the criterion variable has been determined for the variable *jump from a static position with preparation* (MCMJ; $r=0.31$).

The fifth variable is the criterion variable *length of steps* (KDK). The connection between the predictive group and the independent variable equals $R=0.42$ and is statistically significant. The predictive group has explained 18% of the variance, while the connection between the predictive and criterion variable has been determined for the variable *jump from a static position with preparation* (MCMJ; $r=0.46$).

The results of the stepwise forward regression analysis have showed that there is not a connection between the predictive group of variables with the third criterion variable *duration of flight* (KTL). The reason for that may be in the insufficient take-off power of the legs at the time of the girls' sprinter's running take-off.

Table 5. shows the correlations between the variables *three connected jumps* (MTPS) and *jump from a static position with preparation* (MCMJ). According to the obtained results it can be concluded that there is a statistically significant correlation between the analyzed variables for both girls and boys.

DISCUSSION AND CONCLUSIONS

The results of the forward stepwise regression analysis show that with boys there is a significant connection between the variables *50 metres running time* (KT50) and *three connected jumps* (MTPS) (table 3.), while with girls the first variable is connected to the variable *jump from a static position with preparation* (MCMJ) (table 4.). Smirniotou et al. (2008) have determined the tests jump from a static position (squat

jump) and jump from a static position with preparation (countermovement jump) as best predictors of sprinter's running. Maulder, Bradshaw and Keogh (2006) have stated that the jump from a static position with preparation has the highest predictive value for the 10 metres sprint from a start block.

When talking about boys, the variable *jump from a static position with preparation* (MCMJ) has a statistically significant connection with the criterion variable *duration of flight* (KTL), while with girls of a younger school-age the same variable is significant for the criterion variable *duration of contact* (KTK), *frequency of steps* (KFK) and *length of steps* (KDK). Babić (2005) has determined that examinees with a better developed explosive power achieve a longer step in sprinter's running.

The correlations between variables *three connected jumps* (MTPS) and *jump from a static position with preparation* (MCMJ) are statistically significant. These correlations' results were expected since both variables were used to measure the explosive power of the legs. In both motor tests the eccentric-concentric muscular activity was dominant, but in the *jump from a static position with preparation* test (MCMJ) examinees lower themselves to a half-squat and then perform a vertical jump while in the *three connected jumps test* (MTPS) examinees perform the test without previous preparation.

Since the variable *jump from a static position with preparation* (MCMJ) has a dominant effect on the analyzed kinematic parameters compared to the variable *three connected jumps* (MTPS), the reason should be looked for in the fact that in the *jump from a static position* test (MCMJ) the eccentric-concentric muscular activity is emphasized and it equals the one in sprinter's running (Smirniotou et al., 2008).

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