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USE OF SUPRA-MAXIMAL SPEED MEAN IN MAXIMAL RUNNING SPEED DEPMENT

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Abstract

In the contribution authors explain kinetic parameter changes in supra-maximal running speed and compare them with parameters in maximal running speed. For learning these parameters there is used special apparatus Locomometer and for supra-maximal speed reach is used appliance Speedy. In the research were involved (n = 57) Slovak and Slovenian male sprinters. The sport performance level of them was from 10.90 – 11.67 s and age of them was 17 – 31 years. Authors found by long-term research that usable supra-maximal speed in praxis is 105 – 108% of individual maximal running speed and this represent pulling force 20 – 40 N. They show the possibility how it can be performed in training process with appliance Speedy. In conclusions authors are also given recommendations for practical use in training units.

1. Introduction

In nowadays sports successful results very often depend and are performed though maximal or very high (optimal) speed. Manifestation of it enables very good preparation and training from the point of view of maximal running speed that can be the base for any further transformation in motor acts and element movement structures during sport competitions or matches. That is why the development of speed abilities is very topical problem of the sport theory and practice.

During speed abilities development we must realise that "speed is mostly developed by speed." That's why the most effective and most frequent method of the speed abilities' development is the repetitive method in maximal intensity. In practice there is very often used the contrast method, which combines the intentional application of natural, easier and more difficult conditions in running training.

The creation of easier condition for the motor activity realisation is enabled by changing of several (mostly kinematic) parameters which is manifested in reaching higher than maximal speed in natural conditions. We talk

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about over maximal, sometimes over limited or supra-maximal speed. Easier conditions can be done for example in the natural conditions' use (running on the wind, down-hill running) or outdoor force (various means of pulling) that are affecting the sportsman. At present the sport practice use large quantity of means aimed at the supra-maximal speed reach. From position of supra-maximal speed means' use there is Naglak (1974); Vanderka (1998); Sedlacek et al. (2004); Sedlacek, Kostial, and Zvonar (2014) and some others, that easier conditions can be done only up to the level that enable to reach such a speed which is the runner able to reproduce in natural conditions in the short period. Chomenkov (1974); Bacvarov (1986); Kolodij, Lutkovskij, and Uchov (1985) likewise Maksimenko and Tabacnik (1985); Verchosanskij (1996); Vanderka (1998); Sedlacek et al. (2004); Sedlacek, Kostial, and Zvonar (2014) and other focussed that the selection of the supra-maximal speed means ought to be approached critically with responsibility, for the positive transfer speed abilities from one movement to another, is possible only by identity (similarity) of their structures (kinematics and dynamics) and the character of neuro-muscular sportsman's reaction.

With the bio-mechanic of supra-maximal speed dealt for example Zukov & Sabanov (1983); Holland (1984); Bosco & Vittori (1987); Mero et al. (1987); Mero & Komi (1990); Dintiman et al. (1997),. All confirmed the different dynamism of their parameters changes during the running increase of speed. For example on the running speed rise share stride length and stride rate but in higher velocities their relationship changes at undesirable way. There is an inadequate increase of the portion of stride length, on the other side decrease stride rate. There are also watched average forces changes in vertical and horizontal contact reaction components, this often forces mainly lower extremities to act in the passive part of action angle of contact time like a break. Thus special co-ordination structures and the transfers into natural conditions are hardened.

Many researchers confirmed the positive influence of supra-maximal speed means' use for the maximal running speed changes and in this way also level increase of sport performance in short distance runs (athletic sprints and hurdling). From the stated above is clear, that for the reaching of the relatively similar positive effect were used more approaches, mostly based on empirical experience, partly even experimentally tested. But there can be said that the sport practice has not till now available scientifically justified methodology of the supra-maximal speed means' application.

Analysis of the supra-maximal sprint's problem:

- confirmed the effect of use means for an increase of the maximal running speed level,
- revealed the insufficient knowledge of the supra-maximal sprint's kinematics structure,
- indicated on change possibilities in movement technique during the supra-maximal speed application,

- manifested great differences from the point of view of load, intensity, frequency, time duration and conditions of impulses application and thus the need for the scientifically explained methodology,

- revealed an importance of further, complex research of the problem, from the point of view of making its use in sport practice.

Several of these problems are solved in this research article.

2. Material and methods

In this research we try to explain kinematic structure changes of running in supra-maximal speed and on this basis to contribute for making optimal methodology of this stimulus application.

Methodology

Regarding the variety, demands and logical link-up of tasks solution we had to work with several groups in longer period. There were involved several groups, that differed in quantity, the level of their preparation and sport performance. Totally members of our groups (n = 57) were short distance runners and hurdlers (100 – 400 m), who were in the phase of special and top-level sport preparation. Their age ranged from 14 to 31years and sport performance level in 100 m sprint from 11.67 to 10.90 s. Tests were performed in relatively stable conditions of Bratislava indoor stadium in the preparation period (November – March) in years 1990 – 1994.

The maximal running speed was learned in the run of 20m flying start with 20m approach. On the same distance the sprinters passed the supra-maximal speed run. The reach of it was enabled with help of pulling appliance known as SPEEDY (fig. 1). The runner "pulling athlete" by the force of his pull and by the mean of a single pulley quickens the partner who reaches double velocity. Later substitution of fixed anchor by mobile (regulated) enabled us to regulate pulling force. The pulling forces of 20, 30, 40 and 50 N were applied.

Tested sprinters passed mostly runs:

- 2 x 20 m with flying start (better of two results served as criterion of the maximal running speed),

- 2 – 8 x 20 m in the supra-maximal speed with different pulling forces (in the analyse were taken results of all measurements),

- 20 m with flying start passed only selected individuals for finding immediate training effect.

For detecting and processing basic kinematics characteristics of sprinters motor activity during the maximal and supra-maximal speed running we employed the measuring instrument "Locomometer" (Kampmiller, Holček, Šelinger, 1993; Šelinger & Holček, 1993). The system works on-line, it is based on connection and disconnection of electric current and the length of thin metal rope pulled by runner; parameters are available in 1 min. after finishing tested run (fig. 2).

We worked with following parameters:

- average and immediate running speed,

- stride rate and length,

- time periods of single steps, their contact and flying time,
- derived parameters for example technique stability expressed by variance and standard deviation of measured values, effectiveness given as a rate of flying and contact time, activity given by rate of stride length and lasting of contact time etc.

In this research we connected appliance Speedy with apparatus Locomometer. In such a way we learned parameters of running stride also during supra-maximal running speed (fig. 3).

During processing of the parameters we used logical methods, and methods of mathematical statistics. Gained variables are described by meaning of central values differences of pair character data was used Wilcoxon t-test. Relations between variables are estimated by the Spearman pair correlation coefficient and regression analysis. Reached empirical research results in the confrontation of other authors' results as well as practical experience are confronted by logical evaluation of gained facts (analytic, synthetic and inductive – deductive methods), on the basis of which we formulate pieces of knowledge and conclusions of research.

3. Results and discussions

Changes of kinematic parameters of sprinter motor activity during supra-maximal speed running

We performed 143 measuring in natural and 85 in easier conditions. The use of the pulling appliance with fixed anchor did not enable us to define and stabilise the pulling force. That is why runners were reaching the different level of the supra-maximal speed. The average time of the maximal speed running was 2,167s and the supra-maximal speed 1,936s. It means that sprinters reached on the flying 20m run in easier conditions in average better time of 0,231s that is they were faster at 10,66 % like in the maximal speed running.

The statistical characteristics of kinematic parameters of running in natural and easier conditions are presented in table 1. In the supra-maximal speed conditions can be seen considerably, statistic highly significant changes of all parameters apart from practically not changed stride rate. It seems that supra-maximal speed of sprinters had been reached predominantly by increase of stride length.

Further by the mean of the pair correlation analyse we were looking for the coherence between running speed and other parameters (fig. 4, 5, 6). In the natural conditions we did not confirm the significant relations of running speed with lasting of contact or flying phases, even with stride rate (fig. 4, 5, 6). Very small relationship we founded only between the velocity and length of running stride. In easier conditions there is a clear tendency that faster sportsmen have shorter contact time (fig. 5) and close relationship can be seen between the velocity and stride length (fig. 6). Except this we founded only insubstantial relationship between the velocity and stride rate (fig. 6) and the relationship of

the velocity with time of lasting of flying phases did not reach statistical significance (fig. 4).

On the basis of positive changes of contact and flying times and stride length and vice versa practically unchanged stride rate as well as on the basis of relative high correlation between the supra-maximal speed and stride length, we suppose that in easier conditions runners were passive. The reach of higher quality in several parameters we explain mainly by the activity of outer force: pulling apparatus.

The pulling appliance on one side enable considerable increase of running speed but the kinematics structure of running is changed from the point of view of higher level of speed – strength co-ordination abilities in undesirable way. So called "live pulling" with the help of fixed anchor indicates various pulling forces and at the same time with the supra-maximal level speed increase (higher than optimal) becomes deeper the negative character of the several parameters' changes of movement activity (for example stride length).

Comparison of trends of kinematic parameters changes between maximal and supra-maximal running speed

Next part of our research is devoted to looking for optimal pulling force. In the first part of the solution of this problem we decided to find trends of changes of selected kinematics parameters of running at various levels of supra-maximal speed.

For solving this task we performed 45 measurements in natural and 26 measurements in easier conditions. On the figures 7 and 8 can be seen trends of kinematics parameters' changes of the maximal and supra-maximal speed running. On axis x there is expressed running speed of sprinters during 20m flying run, on axis y stride length and rate (fig. 7) and lasting of their contact and flying phases (fig. 8).

In natural conditions increases the running speed from 9 to 10m.s^{-1} in such a way that stride rate manifests from the start mild decrease and then sharply rises, the stride length has opposite tendency (increase and then decrease), contact phase shortens and flying phase has increasing and then decreasing course.

In conditions of running with pulling apparatus, when runners get into the zone of the supra-maximal speed 10 – 11m.s^{-1}, becomes significant change - stride length increase, and the tendency is permanently graduating. Stride rate does not change at all, has stabile character. Lasting of contact phase sinuously decreases and flying phase rises in the same way.

From the levels and tendencies of single kinematics parameters changes of running by their mutual comparison in natural and easier conditions comes out their controversial character. We confirm again that the supra-maximal running speed with the pulling apparatus is reached by substantial stride length rise with simultaneous keeping the stride rate that presents controversial tendency in the comparison with running in natural conditions. This fact gives rise the question if from the point of view of motor learning and the theory of motor abilities

development applied methodology of the supra-maximal speed running is effective or not.

Making optimal pulling force of runner by the supra-maximal speed running application

In the second half of this problem solution we started to regulate the magnitude of pulling force by the use of the frictional mechanism with the help of the weight in the pulley "Speedy" appliance. Sprinters performed 6 – 8 runs on 20 m from flying start in the supra-maximal speed with four increased pulling forces (20, 30, 40, 50 N).

The condition of making the pulling force optimal is connected with parallel creation of conditions for stride rate increase. From the methodical point of view we consider as a decisive not to pull the sprinter by too high force in order to be able to do movements actively with higher frequency on the whole covered distance. This way enables to improve co-ordination on higher speed level of single extremities and the centre of gravity. According performed measurements it seems to us that such an active choice in pulling conditions are able to realise sprinters at pulling force magnitude 20, 30 and sometimes 40 N. Higher force application negatively influences demanded stride rate rise, disproportionately lengthens stride, causes the passive tread-down and forces runners to keep attention to a safe realisation of movement activity.

We mean that in easier conditions is adequate the velocity 5 – 8 % higher than the maximal running speed. The aim of this training is even with help of relatively small pulling force to create faster co-ordination connection of neuromuscular apparatus and thus create dispositions for overcoming potential speed barrier in sprinters training. But even in optimising of pulling force we found inter-individual differences. As a significant we consider fact found that further stride rate increase in supra-maximal conditions are able to realise only those sprinters who dispose its high starting value as well as shorter time of stride contact phase. Stated problem is probably closely connected with the level of special co-ordination abilities. We manifest it on the example of two runners. L.B. (fig. 9) had during natural conditions running stride rate 4.66 Hz and during supra-maximal speed conditions, with individually optimized pulling force 30 N, was able to reach it until 5.07 Hz. Further pulling force increase (40 N) led also at this sprinter to negative phenomenon in running structure that is expressed by frequency decrease. On the contrary at K.S. (fig. 10) with the higher pulling force the stride rate mildly but fluently decreased – from 4.14 Hz to 3.96 Hz by pulling force 50 N.

On the basis of above stated facts we consider as a rightful the demand to respect at the supra-maximal speed application also individual specificity of sportsmen. We suppose that for the sprinter with lower frequency abilities, the application of this method can have even negative influence on their technique. This is only hypothesis that ought to be verified in future research.

Tab. 1 Statistical characteristics of kinematics parameters of maximal and supra-maximal speed running

PARAMETERS		Maximal		Supra-maximal		x1 - x2
		x1	s1	x2	s2	
Speed	[m.s^{-1}]	9,23	0,27	10,33	0,39	- 1,100**
Contact time	[s]	0,113	0,008	0,105	0,008	+ 0,008**
Flying time	[s]	0,114	0,008	0,121	0,007	- 0,007**
Stride length	[m]	2,10	0,10	2,34	0,11	- 0,240**
Stride rate	[Hz]	4,41	0,18	4,43	0,17	- 0,020

** p < 0,01
* p < 0,05

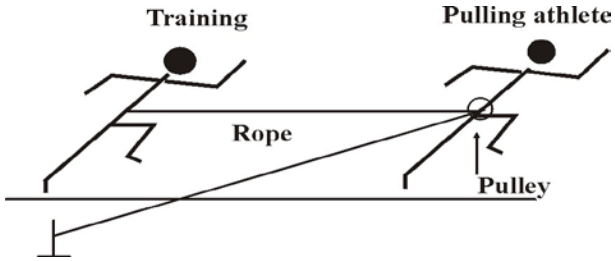

Figure 1. *Diagram of appliance Speedy. Training athlete reaches double velocity (supra-maximal speed) of pulling runner.*

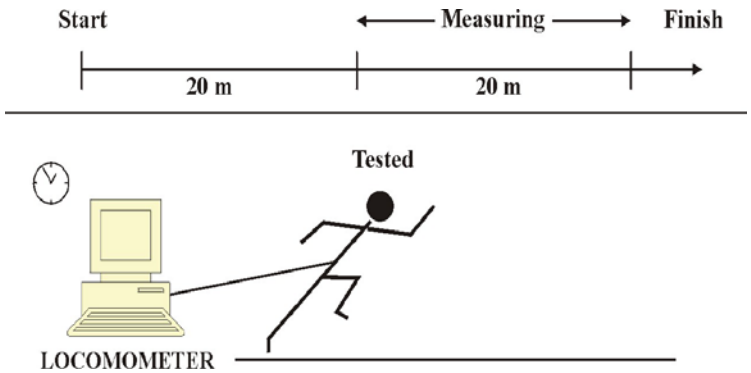

Figure 2. *Diagram of apparatus Locomometer. Connection or disconnection of electric current with length of metal rope enables to measure kinematic parameters of sprint running*

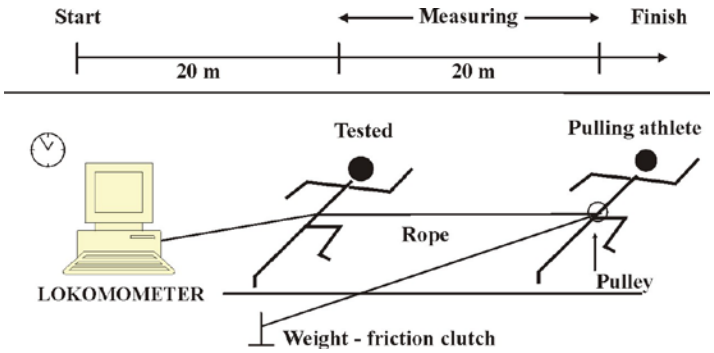

Figure 3. *Diagram of application system Speedy with Locomometer*

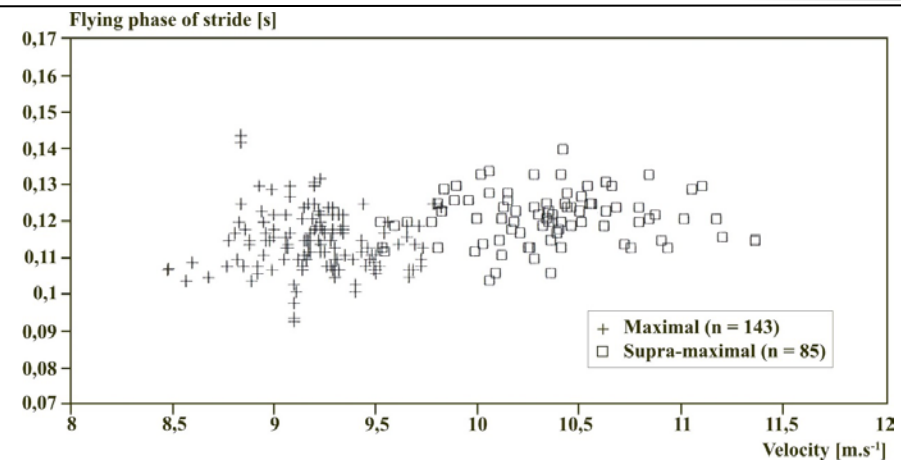

Figure 4. *Relationship of running speed and flying phase of stride at maximal and supra-maximal running speed*

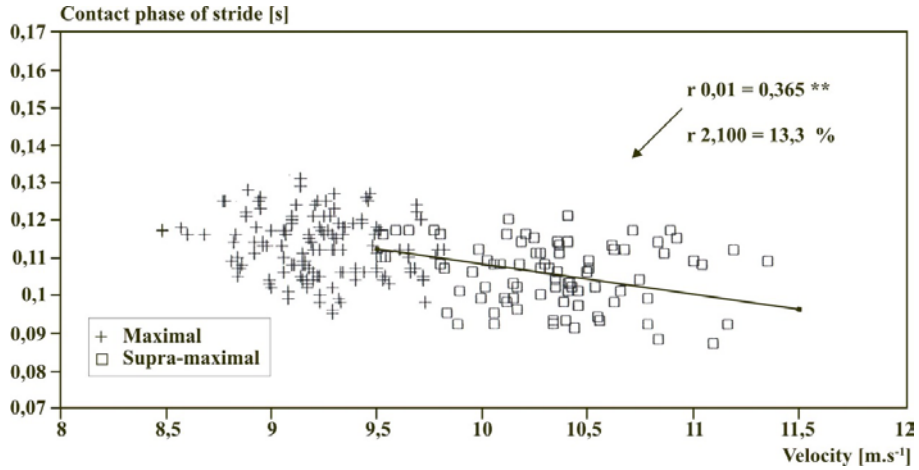

Figure 5. *Relationship of running speed and contact phase of stride at maximal and supra-maximal running speed*

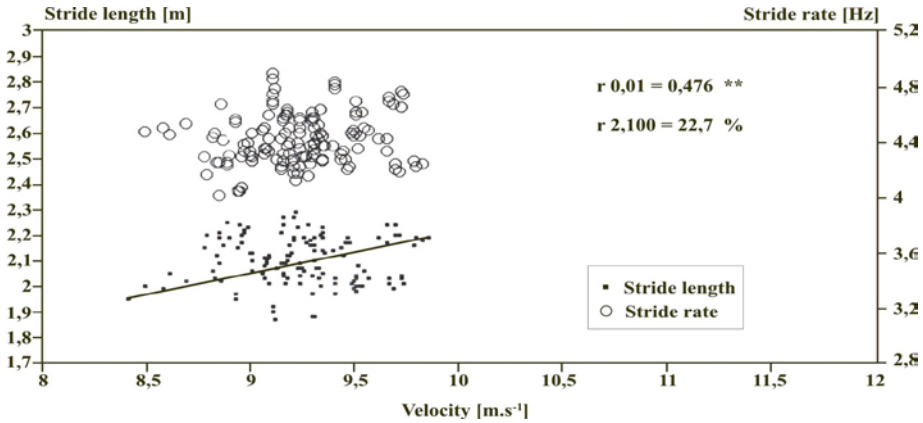

Figure 6. *Relationship of speed, stride length and stride rate at maximal speed running*

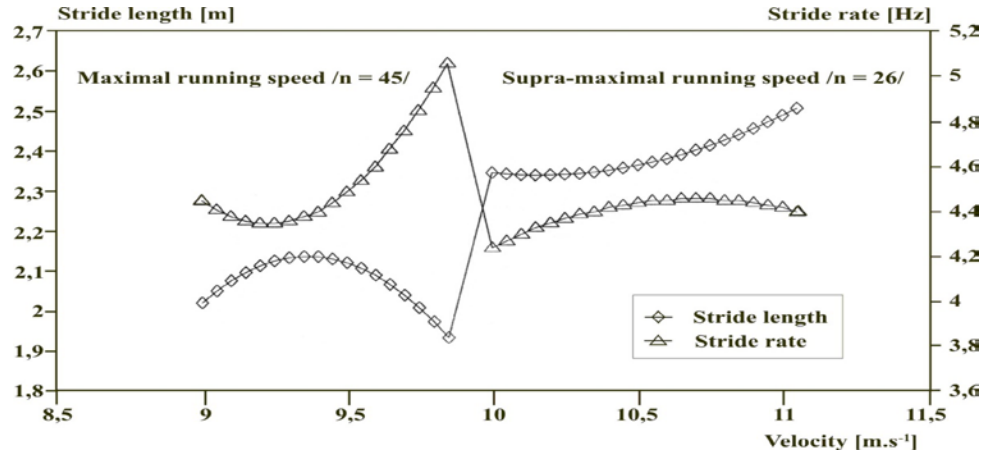

Figure 7. *Regression of kinematic parameters' changes at maximal and supra-maximal running speed*

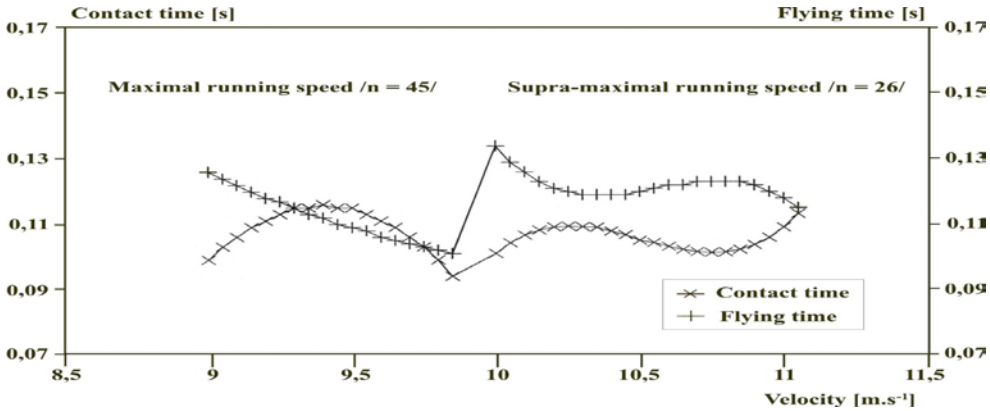

Figure 8. *Regression of kinematic parameters' changes at maximal and supra-maximal running speed*

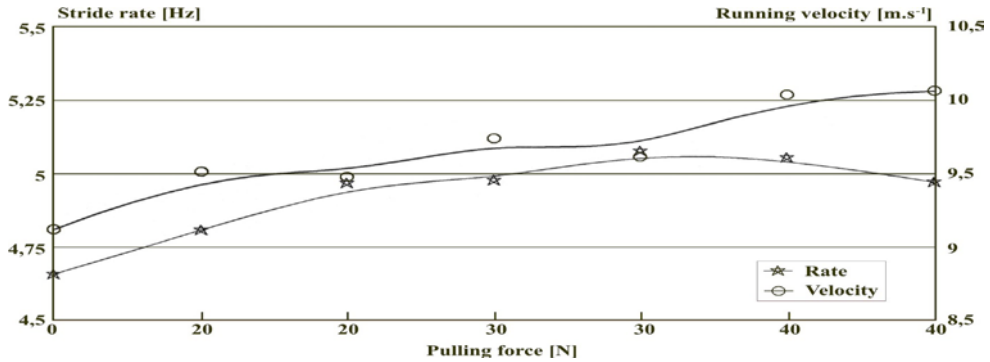

Figure 9. *Trends of running speed changes and stride rate at different pulling forces (runner L.B.)*

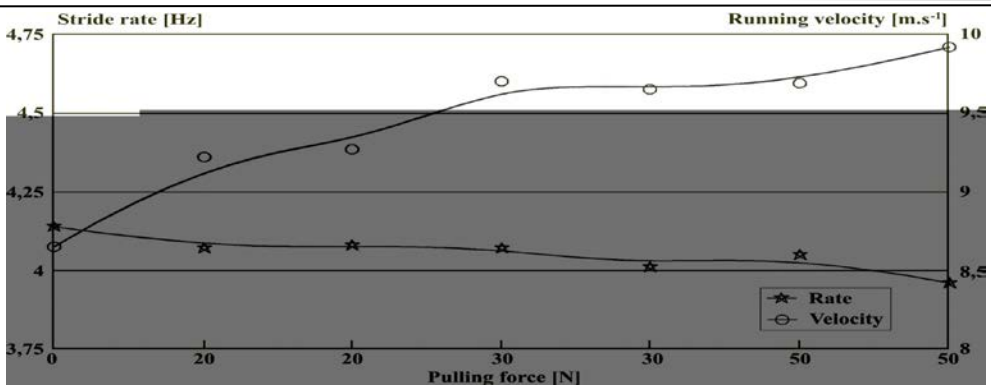

Figure 10. *Trends of running speed changes and stride rate at different pulling forces (runner K.S.)*

4. Conclusions

1. Kinematics characteristic of supra-maximal speed with extremely high pulling force has different character of changes comparing natural conditions. Sprinters in easier conditions act passively. Higher velocity is reached by practically unchanged stride rate, exclusively by stride lengthening. Negative trends of changes of selected movement activity parameters are enlarged with supra-maximal speed increase.

2. Mentioned facts indicate that there is a need of making optimal the stimulation from the point of view of motor abilities' development especially of speed-strength and co-ordination.

3. Making more effective the application methodology of supra-maximal speed requires to make optimal the pulling force magnitude with parallel creation conditions for runner activity increase in order to be able to perform movements with higher (maximal and over maximal) frequency during the whole run. For making optimal this training mean there must be solved the possibility regulate magnitude of pulling force of supra-maximal speed and to this can be enabled for example with use of friction mechanism or with help of weight(s) in pulley appliance of accelerator "Speedy."

4. Regarding the character of movement activity structure's changes and the individual sprinters' specialities (mainly stride rate magnitude in natural conditions) we consider as optimum pulling force 20 – 30 N, sometimes even 40 N, that is manifested by reaching 105–108 % of maximal running speed. Higher force influence negatively demanded stride rate increase, causes passive step down, lengthen inaccurately stride and takes away runners' attention for the safe of movement activity realisation from the view of possibility of injury.

Methodical recommendations for supra-maximal speed application

Magnitude of stimulus: flying runs of 20 – 50 m length with 20 – 30 m approach.

Intensity of stimulus: 105 – 108% of maximal individual running speed that is pulling force 20 – 40 N

Interval of recovery: 3 – 8 min (depends on magnitude of stimulus) Load of stimulus: 4 – 8 runs in one training load that is app. 100 – 200 m

Frequency of trainings: 1 – 2 units weekly

Application in one year cycle: pre-competitive and competitive period.

This method can be applied on good trained, experienced sprinters and sportsmen mostly on top level sport performance level. Preparation from the view of sprint skills lasts several years (minimally 3 year) and we recommend this method to be used in age 17 years and more.

Sprinters must be a very good warmed up just like they would prepare on real competitions; runner must also have an excellent form.

Before systematic application sprinters must be thoroughly informed about mutual cooperation during running.

There ought to be motivated the sportsmen to cooperate in maximal way during runs (activity of subject, effort for maximal stride rate)

Respect individual approach for any sprinter

Keep strictly principles of security and try to eliminate interference of roundabout.

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