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Original Article

Directed asymmetric power action an effectivization factor in sprint coaching

CHIKUROV ALEKSANDR[1], FEDOROV VALENTIN[1], VOYNICH ALEKSANDR[1], KHUDIK SVETLANA[1]
[1]School of Physical Education, Sport and Tourism, Siberian Federal University, Krasnoyarsk, Russia

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Abstract:
This study offers training methodology for sprinters. A principle of directed asymmetric power action (DAPA) on lower limbs in natural conditions of high-speed running is at the core of the methodology. During running workouts we use light weight on a non-dominant leg. An application of the above-mentioned methodology for an experimental group of sprinters in Siberian Federal University during 11 weeks has contributed to modification of ritmo-structural (RS) running characteristics, “speed barrier” overcoming and improvement of seasonal rates on 50 m distance: time and stride quantity decreasing by 0.4 s and 1.3 units, stride rate and stride length increasing by 0.04 Hz and 0.09 m respectively.
Key words: sprint training methods, resisted sprint training, speed barrier, sprint.

Introduction

The problem of sprinter sportsmen methodology improving is relevant at this time. However, the accustomed training methodologies often have a limited effect. The scientific literature analysis has shown that using of the *common training tools* (Zatsiorskiy, 1966), which comprise a systematic repeating of biomechanically rational sport exercises leads to locomotion automatisms and strengthening of RS characteristics – such as stride length and stride rate (Abrosimov, 1977).

Stabilization of motor skills has not only positive impact, but affects negatively through speed growth absence. The absence of positive speed dynamics takes place even at a significant functional skills increasing. Thus, a “speed barrier” or “speed plateau” (Korchemny, 1985, p. 41; Ozolin, 1978, p. 55; Schiffer, 2011, p. 7) are being created, which overcoming is the condition of sporting achievements progress. Counteracting to stabilization of motor skills may be implemented through different approaches and *additional training tools* (Arakelyan, 1970; Bailey et al., 2005; Cissik, 2011; Ilyin, 2002; Gibala 2007; Gonzalez & Beckwith, 2009; Gonzalez et al., 2011; Mehrikadze, 1997; Rumpf et al., 2016; Sergeev, 1999; Sheppard 2004; Schiffer, 2011):

- running performed by means of changes in intensity, intervals length and intervals of relaxing;
- complication and facilitation of running;
- running performed in special conditions using training simulators;
- performing excercises, structuraly different to running (excercises with weights, jumping, local action tools);
- an interface of technical and motor quality training.

Total disadvantages of the above mentioned approaches and additional training tools are:

- insufficient accounting of sprinters’ indivudual characteristics in motor asymmetry of the lower limbs;
- isolated progress of muscle groups, stopping its high-grade application in sprint;
- a significant deviation of RS and another characteristics of running while performing excercises with higher power;
- an increasing in timing of “speed barrier” overcoming.

The lack of information on the possibility of using DAPA as the additional training method in sprinters coaching conductive to elimination of the above mentioned disadvantages served as a precondition for the current research. Thus, the aim of the current research is to define the efficiency of the DAPA method and in the case of its efficiency develop a methodology of sprinters training, based on DAPA method.

Materials and methods

Theoretical basis

It was suggested, that application of DAPA method as influence with light-weight load on the distal part of shin would encourage the following changes in sprint conditions:

1) increasing the full work power;

Corresponding Author VOYNICH ALEKSANDR, E-mail: aleksandr.voynich@mail.ru

2) indirect increasing of non-main mucles' power;

3) direct increasing of the lower limbs' common power according to Fig. 1.

4) predominant work power increasing for the flywheel units' of the loaded leg in additional power cost structure as on the thigh (ω_{i1}-ω_{i2}) and shin (ω_{i3}-ω_{i4}) relocation line segments angular acceleration exceeds such in push and amortization (Fig. 1, A, C). Primarily, the exceedance is linked to presence of non-zero values of initial (ω_{i5}) and final (ω_{i8}) angular velocitis on line segments of push and amortization. At the same time trhough transferring of up to 50% force from swing to pushing leg (Utkin, 1989) a contrubution of non-loaded leg pushing in the additional power cost sctructure for weight transferring may vary in a wide range.

5) work power insignificant increasing of push and amortization for non-loaded leg due to minimal moment of inertia; abscence of work power's changes for swing movements of non-loaded leg (Fig. 1, B,C).

6) due to significant moment of inertia increasing, which is proportional to weight mass and squared degree of angular velocity, some drift in step phase of the loaded leg may occur; a limited drift in step phase of non-loaded leg is also possible.

7) based on an optimal weight mass selection a minimal sprint RS charactiristics' drift is available – in the range lower than 10% provided by the abcence of changes in angular characteristics for running step.

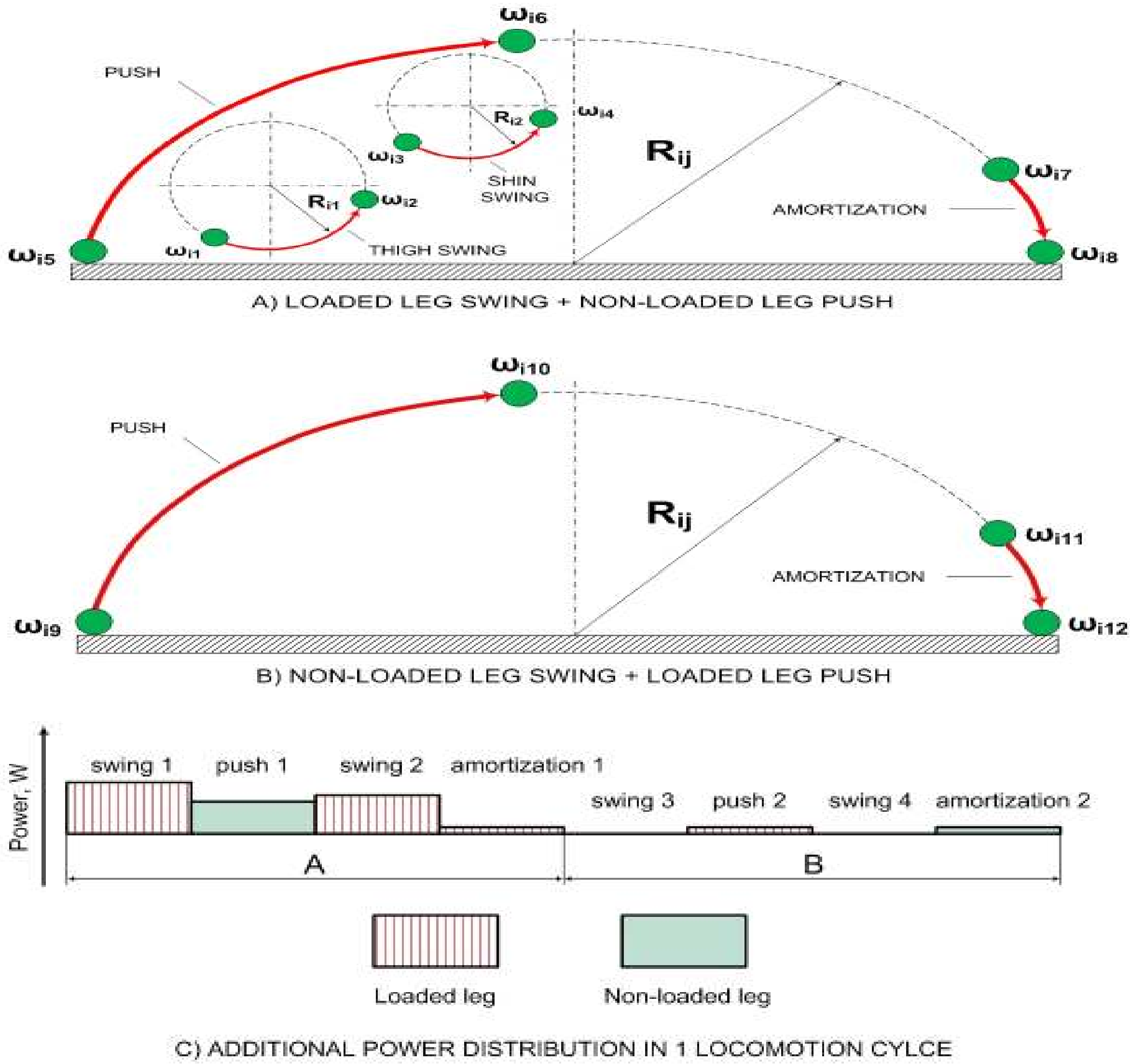

Fig. 1. A schematic model of the additional power ΔP distribution for weight M_i transferring in one locomotion cycle after velocity stabilization

It's evident from Fig. 1, that using weight on one leg leads to additional power costs in 6 from 8 (75%) main movements performed by both legs. According to Fig. 1, additional power, wasted by sprinter in one locomotion cycle may be expressed by the equation:

$$\Delta P = \Delta P_1 + \Delta P_2 + \Delta P_3 + \Delta P_4 + \Delta P_5 + \Delta P_6 + \sum \Delta Pn, \qquad (1)$$

where:
ΔP_1 – additional power for thigh swing by loaded leg, W
ΔP_2 – additional power for shin swing by loaded leg, W
ΔP_3 – additional power for push by non-loaded leg, W
ΔP_4 – additional power for amortization by loaded leg, W
ΔP_5 – additional power for push by loaded leg, W
ΔP_6 – additional power for amortization by non-loaded leg, W
$\sum \Delta Pn$ – sum of additional powers, wasted on non-main muscles actions, including deceleration of swing movements, W.

Additionally wasted powers for swinging, pushing and amortization (Fig. 1) in a general manner may be calculated by the formulas:

$$\Delta P_{swing} = \sum_{i=1}^{n} \left(M_i/\Delta t \right) \times \left(\left(0.5 R_{i1}^2 \times \left(\omega_{i2}^2 - \omega_{i1}^2 \right) \right) + 9.8 \times \Delta H \right), \qquad (2)$$

$$\Delta P_{push} = \sum_{i=1}^{n} \left(M_i/\Delta t \right) \times \left(\sum_{j=1}^{m} \left(0.5 R_{ij}^2 \times \left(\omega_{i6}^2 - \omega_{i5}^2 \right) \right) + 9.8 \times \Delta H \right), \qquad (3)$$

$$\Delta P_{amortiz.} = \sum_{i=1}^{n} \left(M_i/\Delta t \right) \times \left(\sum_{j=1}^{m} \left(0.5 R_{ij}^2 \times \left(\omega_{i8}^2 - \omega_{i7}^2 \right) \right) + 9.8 \times \Delta H \right) \times (1 - k), \qquad (4)$$

where:
M_i – weight mass, kg;
Δt – time of weight transferring, s;
R_i – radius for the circular path of swing movement, m;
R_{ij} – radius for the curved path of movement for push or amortization, m
ω_i – angular velocity according to scheme in Fig. 1, rad/s;
9,8 – acceleration of gravity, m/s^2;
ΔH – change in height positioning of weight for each stage of the locomotion cycle, m
k – utilization ratio for accumulated kinetic energy at transition period from amortization to push.

On the base of the equations (2,3,4) it may be possible to correlate working power increase during (with weight) and after (without weight) application of the approach – due to sprinters' speed progress.

Participants and procedures

Experiment consisted of two stages. During the *1st research stage* a comparative evolution of RS indicators on 50 m sprint distance had been viewed in the following conditions:

1) with no local load;
2) using local light-weight load on dominant leg (DAPA);
3) using local light-weight load on non-dominant leg (DAPA);
4) using local light-weight load on both legs.

Also during this stage a task of defining an optimal value of local load with regard to participant's body mass had been tackled. A limit value of light-weight load was 1% of body mass. 27 female students of Siberian Federal University (SFU) having no sprinter qualification and 18 female students having first grade degree (100 m normative is 13.24 s) or Candidate Master of Sports' degree (100 m normative is 12.54 s) in 100 m sprint were the participants of the experiment. Participants' age was in the range of 17 to 21 years. Experiment was carried out in the covered stadium. Control running distance was 50 m.

During *the 2nd research stage* an evaluation of DAPA method efficiency in sprint coaching was made. 20 female sprinter students (all the participants – SFU students) at the age of 17-21 years participated in the experiment. Participants' qualification was first and second (100 m normative is 14.04 s) degrees in 100 and 200 m sprint, an experience – not more than 5 years. Duration of experiment was 11 weeks. Experiment was carried out in the covered stadium. Control running distance was 50 m. Participants were separated into two groups: experimental and control. On the base of video shooting a comparison of each sportsman's kinematic characteristics of running stride with local light-weight load (from 100 to 500 g) and with no load had been undertaken. Training practices during experiment were carried out by a single training plan. At the same time for the experimental group in trainings aimed at developing speed DAPA approach exercises were provided. Sprinters in control group performed the same exercises, but didn't use the loads.

Data collection and analysis

Result's fixing was made by video shooting. Processing was conducted in "Pinnacle Studio", "Coach's Eye" and "MS Excel" software. Error measurement was not more than 0.3% for timing and 0.4% for stride quantity.

Results

Outcome results of the 1st research stage are shown in Table 1. The subjects' running indicators evaluation with different types of the additional load has shown that changing of space-time running characteristics under asymmetrical load for both groups took place less severely, than in the case of both legs loading. Mostly, a distance speed decreasing is related to stride rate change (Table 1). It was found also that an optimal load value, which provides escaping noticeable disruption the rhythmic structure and running techniques is 0.5 – 0.8% of body mass.

Table 1. Test subjects' indicators in different conditions of 50 m sprint*

№	Beginners			Sportsmen		
	Stride rate, Hz	Stride length, m	Speed, m/s	Stride rate, Hz	Stride length, m	Speed, m/s
1	3.61	1.56	5.63	3.68	1.78	6.55
2	3.49	1.53	5.34	3.55	1.74	6.18
3	3.51	1.52	5.34	3.50	1.75	6.13
4	3.35	1.48	4.96	3.46	1.76	6.09

* 1 – no load; 2 – load on dominant leg; 3 – load on non-dominant leg; 4 – load on both legs

Results of control test for the 2nd research stage were fixed during competition after 11 weeks of training and presented in Table 2.

Table 2. RS indicators progress for 50 m sprint throughout experiment

Indicator	Average value (x± m)		Accuracy of differences in a group
	Before experiment	After experiment	
Experimental group			
Stride length, m	1.79±0.01	1.88±0.02	p < 0.05
Stride rate, Hz	3.85±0.04	3.89±0.05	p > 0.05
Stride quantity	27.9±0.12	26.6±0.09	p < 0.05
Time on 50 m, s	7.24±0.07	6.84±0.06	p < 0.01
Control group			
Stride length, m	1.76±0.01	1.79±0.01	p > 0.05
Stride rate, Hz	3.87±0.04	3.90±0.03	p > 0.05
Stride quantity	28.3±0.08	28.0±0.07	p < 0.05
Time on 50 m, s	7.32±0.06	7.18±0.07	p < 0.05
Indicators of accuracy between the groups			
Stride length, m	p > 0.05	p < 0.05	-
Stride rate, Hz	p > 0.05	p > 0.05	-
Stride quantity	p > 0.05	p < 0.05	-
Time on 50 m, s	p > 0.05	p < 0.05	-

As can be seen, the progress in indicators for experimental group is as follows: time and stride quantity decreasing by 0.4 s and 1.3 units, stride rate and stride length increasing by 0.04 Hz and 0.09 m respectively.

Discussion

Indicators presented in Table 2 demonstrate the sustainable statistical difference between control and experimental groups as well as support the efficiency of the DAPA method. As illustrated in Table 2, the average time value for 50 m distance in experimental group has increased more significantly than in control group (0.4 s compared to 0.14 s) – predominantly due to stride length. Whereas the participants had "beginning and "secondary" sprinters' qualifications the results obtained are in agreement with the earlier researchers' results (Sinning & Forsyth, 1970), according to which at the beginning stage of sprinters' training speed growth is provided both by stride rate and stride length. However, at the beginning stage stride length is dominant factor, which gradually reduces throughout speed progress. Afterwards, when speed indicator follows to the range of "maximal" (11.6 m/s) and "supra-maximal" (10.15 m/s) rates (Bosco & Vittori, 1986), speed progress may occur both through predominant stride length growth and stride rate increasing - even in condition while stride length falls (Hogberg, 1952; Bosco et al., 1984).

There's a special case of "speed barrier" overcoming on Fig. 2, achieved by asymmetry of the lower limbs "smoothing". In such a case "speed barrier" overcoming occurs due to stride length alignment for dominant and non-dominant legs and stride rate growth. It should be pointed out, that asymmetry smoothing or its exception are not necessary conditions for speed progress. Positive results in velocity according to author's approach had been achieved even at stayed asymmetry of the lower limbs - through all the muscles' power growth, increasing in motion frequency and total stride length growth for both legs.

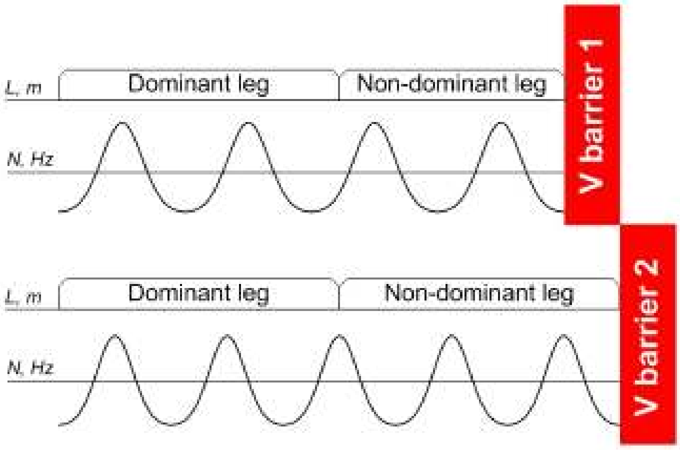

Fig. 2. A special case of "speed barrier" overcoming according to author's methodology (L –step length, N – stride frequency)

On the basis of the experiments authors have developed a multistage model (methodology) of sprinters coaching based on DAPA method. This model consists of 4 stages (Fig. 3):

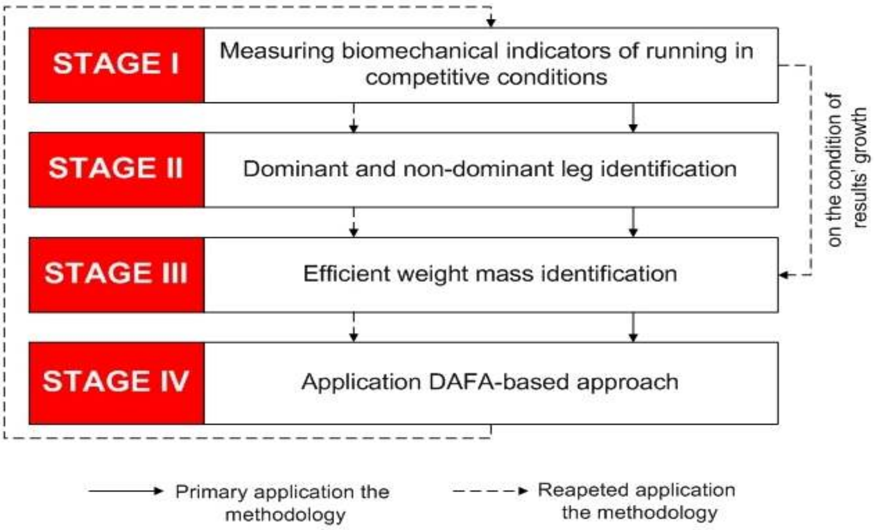

Fig. 3. Model of sprinters coaching using DAPA method

- *First stage* lies in carring out a control test at competitive conditions for detection distance time and basic biomechanical characteristics;
- In *second stage* identification of dominant and non-dominant leg is conducted;
- On the *third stage* load mass value with optimal training influence is set. For that, test with a gradual probe is applied. Kinematic charachteistics of running are compared by means of video shooting and following processing the results of control runnings. A comparison of characheristics is carried out both with and without DAPA. For DAPA-based approach cuffs on non-dominant legs in distal part of shin are used.
- *Forth stage* includes traditional sprint training process with mesocycles and microcycles. At this stage DAPA-based excercises are included. There're two trainings in microcycles, which aimed at developing speed. First speed training in microcycle is *developing.* After two-three days a *toning* speed training with less workload is held. In both trainings DAPA-based excercises are used. Another days trainings include development of coordination skills, functional state improvement and relaxing. In these trainings DAPA approach is not used. Training mesocycle includes up to 8 microcycles. Then basic charecteristics of running in competitive conditions are defined.

Conclusion

Within completed research work the methodology, comprising DAPA approach on the lower limbs in natural conditions of high speed running has been developed and justified. An application of the methodology in sprinters training leads to change of RS running characteristics, contributes to adaptation of biomechanism, functional and nervous sprinters' systems work at a new level. Finally, it facilitates a "speed barrier" overcoming and sport results progress. Currently, the methodology is successfully applied in sprinters coaching at Siberian Federal University, (Russian Federation, Krasnoyarsk).

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References

Abrosimov, V.V. (1977). *Research of sprinter's ritmo-speed motion structure and opportunities to improve it using training apparatus*. (Candidate of science' dissertation abstract, Moscow, All-Union Scientific Research Institute for Physical Culture).

Arakelyan, E.E. (1970). *Experimental substantiation the methodology of application special run exercises for young short-distance runners in basic sport training*. (Candidate of science' dissertation abstract, Moscow, All-Union Scientific Research Institute for Physical Culture).

Bailey J., Ward B., & McLennan A. (2005). Methods of speed training, Sprints and Relays. *Instructional Manual for Coaches* (pp. 37-37). New Zealand: New Zealand Athletics.

Bosco, C., Locatelli, E., & Matteucci, E. (1984). Eine einfache Methode zum Vergleich von Lauf- und Sprungleistungen auf verschiedenen Belägen. *Leistungssport*, 6, pp. 23-26.

Bosco, C., & Vittori C. (1986). Biomechanical characteristics of sprint running during maximal and supra-maximal speed. *New Studies in Athletics*, 1, pp. 39-45.

Cissik, J.M. (2011). Tools for Speed Development. *NSCA's Performance Training Journal*, 10 (4), pp. 11-13.

Gibala, M.J. (2007). High-intensity interval training: new insights. *Sports Science Exchange*, 20 (2), pp. 1-5.

Gonzalez, J., & Beckwith S. (2009). Speed Development in a 100-Meter Sprinter Using a Wetsuit. *NSCA's Performance Training Journal*, 8 (3), pp. 8-10.

Gonzalez, J., Caceres, A., & Guerra I. (2011). Resistive Training for Speed Development. *NSCA's Performance Training Journal*, 10 (4), pp. 7-10.

Hogberg, P. (1984). Length of stride, stride frequency, flight period and maximum distance between the feet during running with different speeds. Arbetis *physiologie*, 14, pp. 431-436.

Ilyin, M.A. (2002). *Technology of application specially crafted excercises in sport education of young short-distance runners.* (Candidate of science' dissertation abstract. Moscow: Federal Science Center for Physical Culture and Sport, 2002).

Korchemny, R. (1985). Breaking the speed barrier. *National Strength & Conditioning Association Journal*, 7 (1). pp. 41-41.

Mehrikadze, V.V. (1997). *Sprinters training*. Moscow: Fizkultura, obrazovanie i nauka publishers.

Ozolin, N.G. (1978). *How to improve speed*. In Jarver, J. (Ed.). Sprints and Relays: Contemporary Theory, Technique and Training. Los Altos, CA: Tafnews Press, pp. 55-56. Originally printed in Legkaya Atletika, reference unavailable.

Rumpf, M.C, Lockie R.G., Cronin J.B, & Jalilvand F. (2016). The effect of different sprint training methods on sprint performance over various distances: a brief review. *Journal of Strength and Conditioning Research Publish Ahead of Print*, 30 (6), pp. 1767-1785. DOI: 10.1519/JSC.0000000000001245.

Schiffer J. (2011). Training to overcome the speed plateau. *IAAF New Studies in Athletics*, 26 (1/2), pp. 7-16.

Sergeev, A.I. (1999). *Methodological techniques of quickness' basic coponents improvement for 13-15 years old short-distance runners.* (Candidate of science' dissertation abstract. Smolensk State Academy of Physical Education and Sport, 1999).

Sheppard, J. (2004). The use of resisted and assisted training methods for speed development: coaching considerations. *Modern Athlete and Coach*, 42 (4), pp. 9-13.

Sinning, W.E., & Forsyth, H.L. (1970). Lower limb actions while running at different velocities. *Med. Sci. Sports*, 2, pp. 28-34.

Utkin, V.L. (1989). *Biomechanics of physical excercises*. Tutorial for students of physical education faculties, pedagogical intitutions and for institutes of physical education/speciality №3114 «Physical education». Moscow: Prosveschenie.

Zatsiorskiy, V.M. (1966). *Physical characteristics of sportsman*. Moscow: Fizkultura i Sport Publishers.