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Original Article

Optimizing sprinters' physical qualities through unconventional training conditions

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Abstract
Background. The problem of developing the speed of movement and speed-strength qualities of sprinters can be solved by applying special exercises in artificially difficult training conditions. **The purpose of the study** is to explore the possibilities of using special training tools, in particular running in artificially difficult conditions at the stage of special physical training of sprinters of mass categories. **Materials and methods:** The study involved young men aged 17-19 years old in the number of 28 people who were engaged in sprint running in the athletics section at the sports school of the Olympic reserve of the city of Kirov (Russia). The pedagogical experiment commenced on November 5, 2022 and concluded on May 24, 2023. Through random sampling, athletes were categorized into a control group, following the standard methodology for training sprinters in natural challenging conditions, and an experimental group, where sprinters practiced in artificially induced challenging conditions. All athletes underwent control tests at the study's commencement and conclusion, including the long jump, triple jump, 20-meter run and 60-meter run. The Student's T-test was employed for result analysis. **Results.** After the end of the pedagogical experiment, the indicators in both groups improved. The sprinters from the control group had higher scores from 1% to 3% in all tests ($p>0.05$). This result indicates the relative effectiveness of the standard technique in working with sprinters aged 17-19 years in natural conditions of difficulty in performing exercises. In the athletes from the experimental group, from the beginning to the end of the study, the indicators improved from 4.5% to 5.9% on all tests ($p<0.05$). This proves the effectiveness of using a set of exercises and load components in working with athletes in artificially created difficult exercise conditions. **Conclusion.** If you use a special set of exercises in artificially created difficult conditions when working with sprinters aged 17-19, then the indicators of speed and strength abilities and speed of movement will significantly improve in comparison with athletes who train in natural conditions of difficulty.
Keywords: long-term training, young athletes, speed qualities, sprinters, training.

Introduction

The modern system of athlete training is a complex, multifactorial phenomenon, including goals, objectives, means, methods, organizational forms, material and technical conditions that ensure the organizational and pedagogical process of preparing an athlete for competitions and achieving the highest sports performance (Rodriguez-Negro et al., 2021; Rodriguez-Negro et al., 2021; Henk Erik Meier et al., 2023). Sports training is an important incentive for young athletes, increases the desire to train hard and persistently, put all their efforts into achieving the goal (Engel & Ackermann, 2018; Christino et al., 2021; Rodriguez-Negro et al., 2021; Eric et al., 2022). At the same time, systematic sports are a powerful factor contributing to the development of the best human qualities, the upbringing of brave, strong, hardy and seasoned people (Dijkstra et al., 2014; Pentidis et al., 2020; Ella McLoughlin et al., 2022; Schubring et al., 2023).

Sports training, being a long-term and year-round process, solves issues that, ultimately, provide an athlete with good health, moral and intellectual education, harmonious physical development, technical and tactical skills, a high level of development of special physical, mental, moral and volitional qualities, as well as knowledge and skills in the field of theory and methodology sports (Lundberg Zachrisson et al., 2020; Zouita et al., 2023)

When starting to plan training loads at each stage, it is necessary to analyze and identify the weaknesses and strengths of athletes' competitive activities, limiting links in physical and technical fitness, training load at various stages of the annual cycle. Such information should serve as a starting point for decision-making and planning. Then the coach must clearly represent the individual model of the athlete's running in competitive conditions for the planned result, as well as the required level of physical and technical fitness. All these data will allow the coach to choose training tools more carefully (to correct certain shortcomings), the volume and intensity of the load in the annual training cycle (Thompson et al., 2022; Staff et al., 2023).

Based on the data available in the scientific and methodological literature, the construction of a one-year training cycle for sprinters has the following cyclist (Milloz et al., 2021; Rauff et al., 2022):

1. General preparatory stage (November-February) 11-13 weeks (improvement of general physical fitness and development of basic physical qualities).

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2. Special preparatory stage (March-May) 11-12 weeks (improvement of special physical training, improvement of equipment and development of elements of tactics, improvement of speed-strength and special running training).

3. The competition period (June-July) is 6-8 weeks (achieving a high level of special training and its implementation in the most responsible competitions).

4. The transition period (August-October) is 11-12 weeks (load reduction, active rest, recovery, it is necessary to create conditions for maintaining fitness in order to start a new large cycle from a level exceeding the previous one)

According to experts and coaches, the intensity of work should sometimes exceed the intensity required at competitions. In a sprint, for example, this task can be solved by using exercises performed in complicated, ordinary and lightweight conditions combined in a certain sequence (Jones et al., 2019; Jenkins et al., 2022).

The ways to complicate the conditions for performing a competitive exercise can be divided into two groups:

1) natural difficulty conditions – running on sand, running uphill, running on snow, on water, running up stairs;

2) artificially created conditions of difficulty – running with negative traction (with rubber shock absorbers or rubber resistance, fixed to the lower part of the shin, hip; with a parachute; with a tire; with a winch – technical devices that make movement difficult, automatically regulating the force of traction), running with a vest or belt (up to 8% of the body weight), running in cuffs attached to the lower part of the shin, running with the resistance of a partner (Swindell et al., 2019; Rauff et al., 2022).

The frequent change of resistance, due to the two-way influence, contributes to the greatest manifestation of the speed parameters of movements with weights (Swindell et al., 2019; Gembris et al., 2022).

In order to increase the speed of movement with a weighted resistance, under the influence of working with a light one, a constant alternation of resistances is necessary. After working with weighted resistance, you can perform exercises at an increased speed of two or three movements with light resistance (Jones et al., 2019; Milloz et al., 2021). The use of weighted and lightweight resistances makes it possible to selectively influence the increase in the level of use of individual components of special speed and strength qualities (speed or strength) and allows you to dramatically increase the volume of special exercises (Haugen et al., 2019).

If we use some ways to complicate the conditions for performing a competitive exercise, then the number of throwing exercises in a year's training will increase 6-10 times for javelin throwers, 2-2.5 times for disco balls, 2-3 times for hammer throwers, 1.0–1.5 times for short–distance runners (Bezodis et al., 2019; Gembris et al., 2022).

Some experts believe that a sprinter's strength training program may take the form of weight training (isotonic training), isometric training, weighted vests, shoes, resistance training with a partner, or gymnastic exercises. It is important that running with resistance or with weights is combined with running under normal conditions. This gives a significantly greater increase in running speed than just training in a sprint. The use of resistances allows you to increase the frequency and efficiency of leg movements (per second) and increase the strength of the muscles that participate in sprinting. Creating resistance is also a means of increasing running speed (Bezodis et al., 2019; Gembris et al., 2022). The sprinter's speed and strength training began to be carried out not so much by working with a barbell, as by jumping exercises and "power" running, that is, running in difficult conditions. All power must be placed within a certain framework. All types of strength training are auxiliary and the closer they are to the main competitive movement, the better (Henk Erik Meier et al., 2023).

Running in difficult conditions makes it possible to maintain the basic structure of a competitive exercise. But there is a problem related to the qualitative and quantitative measure of variability. It needs a deeper and more specific development. In addition, there is no consensus on which sequence is best followed in the application of complicated and ordinary conditions. In the modern scientific literature, there are several studies that prove the effectiveness of using a particular technique to develop the physical qualities of athletes in difficult conditions (Jones et al., 2019; Rodriguez-Negro et al., 2021; Rauff et al., 2022; Henk Erik Meier et al., 2023). However, a comparative analysis of special training tools in natural and artificially difficult conditions is presented for the first time, which is the novelty of this study.

The hypothesis of the study is that it can be assumed that the use of special means in training, such as weights for various segments, will increase the speed and speed of movement of sprinters aged 17-19 years.

The aim is to explore the possibilities of using special training tools, in particular running in artificially difficult conditions at the stage of special physical training of sprinters of mass categories.

Tasks

1. To study the features of using special training equipment for sprinters according to scientific and methodological literature.

2. To develop and test a special set of exercises in artificially difficult conditions for sprinters aged 17-19 years, to propose load components.

3. Compare the results obtained with previous studies on the problem.

Materials and methods

Study participants:

The study involved young men aged 17-19 years old in the number of 28 people who were engaged in sprint running in the athletics section at the sports school of the Olympic reserve of the city of Kirov (Russia). All athletes underwent an in-depth medical examination and were admitted by a group of doctors to training and competitive activities.

All procedures met the ethical standards of the 1964 Declaration of Helsinki and were approved by the local university ethics committee.

Organization of the study:

Since November 5, 2022, the general preparatory stage has begun for all athletes of the sports school. At the first lesson, all athletes took control tests. The selection of control tests for the study of the motor training of sprinter athletes was carried out taking into account the information available in the literature on the factorial, correlation significance of tests and their reliability (McGuigan et al., 2013; Chaabene et al., 2018; Lockie et al., 2019; Barbosa et al., 2022):

1. Long jump from a place (assessment of speed and strength qualities);
2. Triple jump from a place (assessment of speed and strength qualities);
3. Running 20 meters per stroke (evaluation of the sprinter's maximum running speed);
4. Running 60 meters from a low start (assessment of speed abilities).

Until February 28, 2023 (before the end of the general preparatory stage), all athletes practiced according to the same methodology and performed the same amount and intensity of load. All athletes used the means to develop the physical qualities necessary for a sprinter (Milloz et al., 2021; Rodriguez-Negro et al., 2021; Rauff et al., 2022):

1. Accelerations of 50-60 meters × 6-8 times.
2. Acceleration of 60-80 meters × 3-4 times.
3. Acceleration of 40 meters × 8-10 times.
4. Acceleration from a low start to 40 meters × 8-10 times.
5. Throwing from various starting positions (weight 3-4 kg).
6. Running on soft ground 2 × 150 meters (freely).
7. Running exercises with a 2 kg belt.
8. Jumping from a place in length 12-15 times.
9. Jumping with getting branches 15-20 times.
10. Variable running -80 meters fast after 20 meters jogging.
11. Running uphill 5× 100 meters.
12. Running up the stairs.
13. Running down the mountain 3-4 times for 60-80 meters.
14. Jumping exercises of 30-40 meters each exercise, 3-4 repetitions.
15. Repeated running with an intensity of 85-90%.
16. General physical training exercises with weights (25-40 kg): pushes, pulls, jerks, lunges in motion, jumps with a change of leg position – each exercise is 2-3 series 8-10 times.

From March 1 to May 24, 2023, the main pedagogical experiment was conducted at a special preparatory stage.

By random sampling, all children were differentiated into 2 groups of 14 athletes each.

The athletes of the control group practiced according to the generally accepted method, using special training tools in natural conditions of difficulty (Haugen et al., 2019; Henk Erik Meier et al., 2023): a set of jumping exercises at the stadium, running up stairs, extreme running on sand, running uphill, running in the snow.

The athletes of the experimental group trained according to the proposed method using special means in artificially created difficult conditions. An example of exercises in an experimental group:

1. Running and jumping in ankle cuffs (weight up to 500 grams)
2. Running and jumping in hip cuffs (weight up to 700-900 grams)
3. Running and jumping with a weight belt (weight 2-5 kg)
4. Running with a partner's resistance;
5. Running with a tire;
6. Running with holding on a rubber shock absorber.

Running and running exercises with weights were used in accordance with the basic methodological techniques:

– The length of the segments of running with weights usually does not exceed 50 meters

– The speed of overcoming the segments should be equal to 80-90% of the maximum capabilities of the athlete.

– The number of repetitions in one series – 2-3 times

– Rest between repetitions in a series – 3-4 minutes.

– The number of episodes per workout is 2-4.

– Rest between series of 6-8 minutes or until full recovery (when the heart rate drops to 114-120 beats / min.)

The development of speed in its complex expression is best achieved by using running on segments of 50-80 meters with maximum and near maximum speed.

In order to determine the effectiveness of the use of physical training in both groups, after the end of the special preparatory stage on May 25, 2023, all athletes re-passed the control standards.

Methods of mathematical statistics

After the end of the pedagogical experiment, methods of mathematical statistics were used, which are widely used in pedagogical research (de Winter, 2019; Mishra et al., 2019).

The generally accepted characteristics of the static distribution were calculated:

X – arithmetic mean;

δ – standard deviation;

m – standard error of the arithmetic mean;

When comparing the indicators, the reliability of the differences was determined by the Student's T-criterion at $p \leq 0.05$.

Results

In order to objectively verify the effectiveness of the proposed method in comparison with the generally accepted method, it is necessary to identify changes in intra-group indicators of physical fitness, as well as their differences in level in groups at the beginning and at the end of the experiment (intergroup differences).

Table 1 shows the baseline values in the control and experimental groups for all tests.

Table 1. Comparison of the performance of athletes from both groups before the start of the study

Control tests	Control group			Experimental group			t	p
	X	δ	m	X	δ	m		
Jump	240,6	8,5	2,7	240,3	7,9	2,5	0,08	>0,05
Triple jump	709	31,5	9,97	707	34,7	10,9	0,14	>0,05
Run 20m	2,87	0,19	0,06	2,89	0,16	0,05	0,26	>0,05
Run 60m	7,76	0,32	0,1	7,84	0,32	0,1	0,57	>0,05

The analysis of the initial data in Table 1 indicates the relative homogeneity of the groups, since before the experiment both groups were almost equal in terms of physical fitness. For all four indicators, the differences are unreliable ($p>0.05$).

After applying the proposed training tools at the stage of special physical training, repeated testing was carried out for the same indicators and the results were obtained, which are reflected in Tables 2 and 3.

Table 2. Comparison of the performance of athletes from the control group at the beginning and at the end of the study (n=14)

Control tests	Before			After			t	p
	X	δ	m	X	δ	m		
Jump	240,6	8,5	2,7	243	7,3	2,3	0,68	>0,05
Triple jump	709	31,5	9,97	730	20,5	6,5	1,76	>0,05
Run 20m	2,87	0,19	0,06	2,8	0,13	0,04	1	>0,05
Run 60m	7,76	0,32	0,1	7,6	0,02	0,01	1,6	>0,05

Table 2 shows that when comparing the indicators for all tests in the control group from the beginning to the end of the study, no significant differences were found, but their positive growth should be noted. At the same time, significant changes occurred in the experimental group for all tests (Table 3).

Table 3. Comparison of the performance of athletes from the experimental group at the beginning and at the end of the study (n=14)

Control tests	Before			After			t	p
	X	δ	m	X	δ	m		
Jump	240,3	7,9	2,5	253	6,3	2,5	3,7	<0,05
Triple jump	707	34,7	10,9	739	14,2	7,4	2,7	<0,05
Run 20m	2,89	0,16	0,05	2,72	0,13	0,04	2,8	<0,05
Run 60m	7,84	0,32	0,1	7,4	0,01	0,01	4,4	<0,05

The analysis of Table 3 shows that from the beginning to the end of the study, the athletes in the experimental group had positive and significant changes in all control tests.

To illustrate the results of the experiment, they can be presented in the form of a diagram, all indicators from the beginning to the end of the study in both groups are presented in percentage terms in Figure 1.

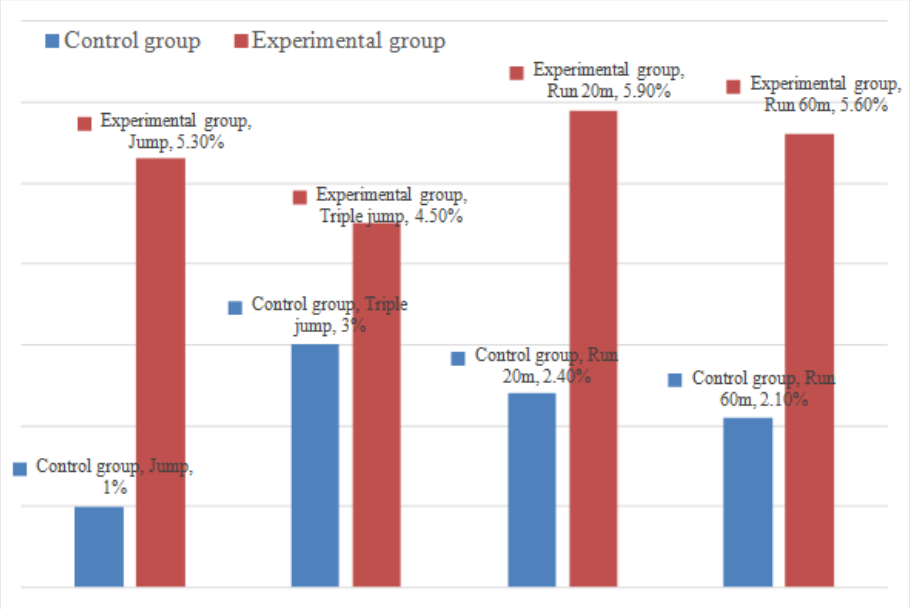

Figure 1. The increase in indicators in both groups from the beginning to the end of the study.

Comparing the data in Figure 1 from the beginning to the end of the study in athletes of the control group and the experimental group and analyzing them, we can consider sufficient grounds to say that the use of special means in training in artificially difficult conditions is more effective than their use in normal and naturally difficult conditions.

Discussion

Before the start of the pedagogical experiment, the peculiarities of using special training tools for sprinters were studied. An analysis of the scientific and methodological literature on the problem has shown that with a properly organized training process, special training tools at the stage of special physical training can be quite effective. Such features include natural conditions of difficulty in performing the exercise, and artificially created difficult conditions for performing the exercise (Rodriguez-Negro et al., 2021; Rauff et al., 2022).

For the first time, a special set of exercises in artificially difficult conditions for sprinters was developed and tested, specific load components for athletes aged 17-19 years were proposed.

According to the results of this pedagogical experiment, it was revealed that athletes from the control group who practiced according to the generally accepted method, using special training tools in natural conditions of difficulty, were able to improve their performance during the study period. In the "Long jump from a place" test, the indicators improved by an average of 2.4cm (1%), and in the "Triple jump from a place" test, the indicators became 21 cm higher (3%). In the test "Running for 20 meters from a stroke" improved by 0.07 seconds (2.4%), in the test "Running for 60 meters from a low start" the indicators improved by 0.16 seconds (2.1%). Despite the positive results in all tests in the control group from the beginning to the end of the study, there was no significant increase in indicators ($p>0.05$). Such results may indicate a relatively low, but effective application of a standard technique that uses special training tools in natural conditions of difficulty.

As for the athletes from the experimental group, during the study period they significantly and reliably improved their performance on all tests ($p<0.05$). For example, in the "Long Jump from a place" test, the indicators improved by an average of 12.7 cm (5.3%), and in the "Triple Jump from a place" test, the indicators became 32 cm higher (4.5%). In the test "Running 20 meters from a run", the indicators became higher by 1.7 seconds (2.4%), and in the test "Running 60 meters from a low start", the indicators improved by 4.4 seconds (2.1%). Such results certainly indicate the effectiveness of using a special set of exercises in artificially created difficult conditions and the proposed load components for sprinters aged 17-19 years.

If we compare the results of the study with the methods that exist in the scientific literature, we can note the following.

It has been proven that sprinters include in their training not only exercises with weights, but also jumping exercises, running with a partner's resistance, which gives a positive training effect and improves the competitive result (Jones et al., 2019; Jenkins et al., 2022). This is confirmed by this study.

Many trainers and specialists point out the importance and necessity of using running in conditions of varying complexity to change the speed of running in short stretches. After several runs in difficult conditions (running uphill, over sawdust, over sand) the speed of running under normal conditions increases from the start more significantly than when training under normal conditions (Swindell et al., 2019; Gembris et al., 2022). The result of such studies coincides with the results obtained during a pedagogical experiment in the control group, in

which athletes improved their performance on all tests by practicing according to a generally accepted method, using special training tools in natural conditions of difficulty.

After running on sections of the distance with complicated conditions, in which the runner has to overcome the distance with great effort, at a relatively high pace and speed of movement, running under normal conditions follows. At the same time, special endurance is also improved to some extent, since extremely fast movements in this case are performed in more difficult conditions (Haugen et al., 2019; Milloz et al., 2021). This is confirmed by the results of the study, which were obtained in both groups, and a positive increase in indicators was recorded for all tests.

In one study, short-distance runners used weights localized at the distal ends of the lower leg. It was assumed that the influence of loads would disrupt the sensorimotor connections of the multilevel system of movements, change the established feedback, and thus the transformed version of the system of movements would be connected to the previously established structure of perceptual processes. After removing the load, all subjects increased their running speed compared to the initial one, increased the pace of running, significantly improved the rhythm and reduced the time of repulsion (Bezodis et al., 2019; Henk Erik Meier et al., 2023). Which is consistent with the results of the study in the experimental group, since athletes were able to significantly and reliably improve their performance on all tests during the study period using special training tools in artificially created difficult conditions (running with rubber shock absorbers with a tire, running with a vest or a weight belt, running in cuffs on the shin or running with a partner's resistance, and others).

Thus, the assumption that the use of special means in training, such as weights for various segments, will increase the speed and speed of movement of sprinters aged 17-19 years was fully confirmed by the results of the study. However, despite the fact that the purpose of the study has been achieved and the hypothesis has been solved, the problem has the prospect of further study. Thus, it is possible to investigate the effect of the proposed load components in athletes over the age of 19 or to conduct additional research that will show the effect of the proposed technique on indicators of other physical qualities.

Conclusion

If you use a special set of exercises in artificially created difficult conditions when working with sprinters aged 17-19, then the indicators of speed and strength abilities and speed of movement will significantly improve in comparison with athletes who train in natural conditions of difficulty.

Weights on the shins up to 500 grams of cuffs, on the hips up to 800 grams, a belt of 2-5 kg are recommended. Running with a tire or with a partner's resistance, running with a hold on a rubber shock absorber. Running with artificial traction – 7-8 kg. There are only 2-4 episodes in one training session. The intensity of running with weights should be 80-90% of the maximum capacity. Rest intervals should be sufficient for recovery. Rest for 3-4 minutes between repetitions, and between series until complete recovery. The results of the study are recommended to be used in the training process of sprinters of mass categories.

The study is promising for further study of the problem of developing the physical qualities of sprinter athletes. Future studies could generalize the findings to even more participants. The results obtained in the course of the study provide great theoretical and practical significance for athletics coaches and a guide to work to achieve maximum results.

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