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Development of Speed in Children Aged 11 to 12 Years Practicing Athletics - Quasi-experimental Non-randomized Study

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Abstract **Background:** The development of speed in primary school children can be improved during the sensitive period of this quality. **Objective:** To analyze the effects of speed and reaction exercises on speed in athletic children between 11 and 12 years old. **Methods:** Quasi-experimental, non-randomized study conducted between September 2022 and March 2023, in which 42 children aged 11-12 years belonging to the Basic sports school No. 8 in Kirov (Russia) were assigned to a control (n=21) and experimental (n=21) group. The classes in the control group were carried out according to the usual athletic training plan, while the experimental group used exercises for speed development. Both groups were evaluated by the tests "Running on the spot", "Shuttle running 10x5 meters" and "Sprint 10 meters". **Results:** The control group did not present significant improvements ($p>0.05$), while the experimental group reported significant improvements in "Running on the spot" (20%; $p<0.05$), "Shuttle running 10x5 meters" (15%; $p<0.05$) and "Sprint 10 meters" (8.6%; $p<0.05$). **Conclusion:** An exercise program focused on speed development in children aged 11-12 years can significantly improve the different manifestations of speed.

Keywords Reaction Time, Motor Skills, Physical Exercises, Track and Field, Child

1. Introduction

Currently, the improvement of educational methods applied to physical education at school level has become a priority for the theory of sports training, due to the complexity of the acquisition and fixation of physical qualities, whose development during the sensitive stages lays the foundations for the formation of fundamental motor skills for the full development of a person throughout his life [1-4].

In this context, it is known that the physical quality of speed is a determinant for the full development of a person, the development of which is strongly determined by genetics [5]. However, it has also been suggested that some external factors dependent on sports training can modulate this quality to a lesser extent, where body composition, physical qualities, neuromuscular capacity, sports biomechanics and biochemical factors can generate a more effective movement [5-10], where the speed has multiple manifestations, among which stand out: reaction speed, movement speed and movement frequency [11-13], whose effects on sports practice act synergistically with the muscle strength, determining sporting success, while the frequency of movements is related to nervous processes in the cerebral cortex, whose results cause muscle tension and

relaxation, as well as intramuscular coordination, being the frequency of movement fundamental for the development of various motor patterns such as sprint running [13-17]. In this sense, the elementary forms of speed manifestation are relatively independent of each other, so that they allow monitoring throughout school development, with the latent time of the motor reaction being an indicator of functional maturity of both the central nervous system and the peripheral neuromuscular apparatus [18-20]. As for the development of speed during the child's stay at school, the indicators that characterize the speed manifestations of a person improve substantially between 9 and 14 years of age, where the sensitive phases determine the optimal time to provide a stimulus oriented towards the development of speed considering that physical qualities cannot be trained with the same intensity and effectiveness according to age. It is worth mentioning that as a result of sexual maturation at these ages, both men and women experience a loss of stability in their sprinting ability and holistic motor actions, making attempts to develop high-speed skills difficult and ineffective [1,20,21]. Similarly, the loss of these favorable periods for the proportion of stimuli oriented to the development of speed generates a loss of the future potential of each person, making the lost time for all skills and physical qualities unrecoverable [3-5,18,20,21].

In this sense, it has been considered convenient to use physical exercises with a versatile orientation in the development of physical qualities, while another current argues that it is necessary to use physical exercises that are focused on motor skills that have high rates of natural growth in specific age ranges of ontogenesis [20]. For this reason, the aim of this work was to analyze the effects of speed and reaction exercises on speed in athletic children aged 11-12 years.

2. Materials and Methods

Quasi-experimental, non-randomized study based on "Transparent Reporting of Evaluations with Non-randomized Designs". [22] Informed consent and assent, as well as the research protocol, were approved by the Research Committee of Vyatka University (Russia), and children were authorized to participate by their parents or legal guardians by signing an informed consent form in accordance with the ethical standards set forth in the Declaration of Helsinki [23].

2.1. Participants

Forty-two children aged 11-12 years participated in the study. At the time of the study, all schoolchildren were healthy and were admitted by a physician, who certified the children's participation in athletic classes, where they were assigned in a non-probabilistic manner to: a control and experimental group, with the selection of participants based on the following eligibility criteria:

Inclusion Criteria

- Children aged 11-12 years attending the Olympic Reserve Sports School No. 8 in Kirov (Russia).
- Children who habitually practice athletics at least 4 times per week.

Exclusion Criteria

- Children who did not agree to participate in the experiment if their parent or legal guardian did not sign the informed consent.
- Children who did not attend the training sessions and evaluations conducted in the classes held at the Olympic Reserve Sports School No. 8 in Kirov (Russia).
- Children who have acute or chronic illnesses that prevent them from participating in the experiment.

2.2. Intervention

The study was conducted in the Olympic Reserve Sports School No. 8 in Kirov (Russia) between September 2022 and March 2023.

The classes of the control group were conducted according to the standard athletics program, [24] while the experimental group was subjected to classes incorporating exercises aimed at improving speed, with the classes being conducted in both groups for four days a week at the same time (Monday, Tuesday, Thursday and Friday from 15:00 to 16:30), but with different coaches, the duration of each workout being 90 minutes divided into a warm-up, main part and cool down, based on the traditional organization used in a physical education class [25-27]. Therefore, in consideration of these aspects, the training sessions of both groups will consider the following:

Control Group

- Warm-up (30 minutes): I incorporate a continuous run (5 minutes) and the execution of general exercises and running technique (25 minutes).
- Main part (40 minutes): I consider repetition of low start technique (20 minutes) and development of coordination skills (outdoor games for 20 minutes).
- Cool down (20 minutes): I incorporate a continuous low intensity run.

Experimental Group

The children in the experimental group performed the same exercises as the control group, but the duration of the warm-up and cool-down was slightly reduced to allow time to perform the series of specific exercises oriented to speed development. This is considering that sprint stimuli generate high levels of fatigue associated with the depletion of the phosphocreatine-related metabolic pathway, leading to a long recovery time between sets [28,29]. Thus, the training session was structured as follows:

- Warm-up (23 minutes): I incorporate a discussion of the training plan (3 minutes) to then give way to a continuous run (4 minutes) and the execution of general exercises and running technique (16 minutes).
- Main part (51 minutes): I consider a series of exercises for speed development (15 minutes): running with acceleration; jerks and accelerations from different starting positions; jerks for short periods with an abrupt change of direction of movement; jumping rope (rotation at maximum speed); long and high jumps with extremely fast repulsion; repetition of the low start technique (18 minutes) and the development of coordination skills (outdoor games for 18 minutes).
- Cool down (16 minutes): I incorporate a continuous low intensity run.

2.3. Objective

The aim of this work was to analyze the effects of speed and reaction exercises on speed in athletic children between 11 and 12 years old. Therefore, it was proposed as an alternative hypothesis that the process of speed development in 11- and 12-year-old schoolchildren will develop more effectively if physical exercises are intentionally applied to develop speed during athletic training sessions.

2.4. Variables

The following tests were used to assess the physical quality of speed:

- 10 x 5 m shuttle run: to start, 4 cones were placed 5 meters apart each. Before starting the test, each student was told to cross two parallel lines located on each cone. In such a way, the student starts the test with his foot behind the starting line (cone A) in sprint start position, proceeding to execute the course in the shortest possible time for ten times at the signal of the evaluator (10 x 5 m). The test will be considered finished when the student crosses the finish line after completing the ten sections, being able to do so with any part of the body, at which time the stopwatch will stop recording the time used [30].
- Running on the spot: each student was instructed to stand with legs hip-width apart and knees slightly bent. The exercise is initiated by moving the right arm flexed at 90° forward, while at the same time raising the left thigh, achieving a 90° flexion over the hip. This movement is alternated between legs and arms; whose main condition is no generation of displacement on the ground [31].
- Sprint 10 m: Each participant stands at the starting line in a standing starting position. The evaluator indicates a countdown ("three", "two", "one" and "go") and the student proceeds to perform a sprint, where the maximum acceleration to the finish line located 10 meters away is timed. Each participant must perform a minimum of three sprints separated by a rest of 2 to 3 minutes for the results to be reliable [32].

2.5. Allocation Method

Each subject was assigned to an experimental group or to a control group in a non-probabilistic manner, the designation being made by matching two groups of equivalent size. Thus, each group consisted of 21 participants.

2.6. Unit of Analysis

Groups of children were considered the lowest administrative unit used to evaluate the effects of the intervention. This consisted of the comparison of 10 x 5 meters shuttle run, running on the spot and 10 meters sprint times.

2.7. Data Analysis

The data were analyzed with the statistical software IBM SPSS Statistics version 27.0 for Windows operating system. The normality of the data distribution was determined with the Shapiro-Wilk test and the homogeneity of variances with the Levene test, reflecting the data through the descriptive measures of central tendency and dispersion; mean and standard deviation. Differences between groups were determined with Student's t-test for related samples, considering the percentage frequency for all analyses, in addition to an alpha level of 0.05.

3. Results

Table 1 shows the analysis of the baseline data, where we can appreciate the homogeneity of the control and experimental groups in the three speed indicators ($p>0.05$).

Table 2 shows the comparison of the speed indicators of the control group before and after the intervention, where no statistically significant differences are observed in the three indicators ($p>0.05$).

Table 3 reports the comparison of the speed indicators of the experimental group before and after the intervention, where statistically significant differences were observed in the three indicators ($p<0.05$).

Table 4 shows the comparison of the speed indicators of the control group and the experimental group after the intervention, where statistically significant differences were observed in the three indicators ($p<0.05$).

Table 1. Indicators of the speed of boys aged 11-12 years before the start of the experiment

Indicators	Experimental group $\bar{X} \pm SD$	Control group $\bar{X} \pm SD$	t	p
Running on the spot	29,24 ± 0,67	29,15 ± 0,57	0,9	>0,05
Shuttle run 10 x 5 m	22,03 ± 0,28	23,00 ± 0,24	0,7	>0,05
Sprint 10 m	2,78 ± 0,05	2,79 ± 0,04	0,95	>0,05

$\bar{X}$: mean, **SD**: standard deviation, **t:** t-statistic, **p:** p-value.

Table 2. Changes in speed indicators in the control group (n=21)

Indicators	Before $\bar{X} \pm SD$	After $\bar{X} \pm SD$	%	t	p
Running on the spot	29,15 ± 0,57	31,1 ± 0,67	5,2	1,98	>0,05
Shuttle run 10 x 5 m	23,00 ± 0,24	21,56 ± 0,22	2	1,4	>0,05
Sprint 10 m	2,79 ± 0,04	2,70 ± 0,03	3,5	1,5	>0,05

$\bar{X}$: mean, **SD:** standard deviation, **%**: percentage, **t**: t-statistic, **p:** p-value.

Table 3. Changes in speed indicators in the experimental group (n=21)

Indicators	Before $\bar{X} \pm SD$	After $\bar{X} \pm SD$	%	t	p
Running on the spot	29,24 ± 0,67	35,12 ± 0,59	20	3,8	<0,05
Shuttle run 10 x 5 m	22,03 ± 0,28	19,00 ± 0,27	15	2,8	<0,05
Sprint 10 m	2,78 ± 0,05	2,54 ± 0,04	8,6	2,5	<0,05

$\bar{X}$: mean, **SD:** standard deviation, **%:** percentage, **t:** t-statistic, **p:** p-value.

Table 4. Comparison of speed indicators of the control group (n=21) and experimental group (n=21) post intervention

Indicators	Experimental group $\bar{X} \pm SD$	Control group $\bar{X} \pm SD$	t	p
Running on the spot	35,12 ± 0,59	31,1 ± 0,67	3,3	<0,05
Shuttle run 10 x 5 m	19,00 ± 0,27	21,56 ± 0,22	2,7	<0,05
Sprint 10 m	2,54 ± 0,04	2,70 ± 0,03	2,2	<0,05

$\bar{X}$: mean, **SD:** standard deviation, **t**: t-statistic, **p**: p-value.

4. Discussion

It is known that in sensitive age periods, specifically targeted effects cause persistent functional changes in the body, which creates favorable conditions for a purposeful increase in the development of physical qualities. Children aged 11-12 years have favorable preconditions for purposeful development of movement speed dependent on natural abilities and nervous processes governed by the central nervous system, leading to the fact that speed-related motor skills are formed between 11 and 12 years and do not vary much in the future [13,16-20].

In this context, the literature expresses that natural growth and sports training provide continuous improvements in the physical qualities necessary for a specific activity, contributing the elements for development [2,5,10,14,21,33]. In this sense, the results of the present work showed a significant and reliable increase in the speed indicators in the experimental group, allowing us to suppose that an exercise program focused on the development of speed applied for 7 months can significantly improve speed by means of specific stimuli of 15 minutes in each training session. However, the physical quality of speed is quite difficult to train because of a genetic predetermination that gives little room for improvement in the sports stimulus [6,10]. In this sense, the results of the present study seem to indicate that the favorable periods for the development of speed are around the age of 11 to 12 years, in agreement with the literature reports [3,5,18,20].

In this context, similar studies show that the minimum training frequency to obtain favorable neuromuscular adaptations to speed development is 3 workouts per week, where significant improvements on the "Shuttle run 10 x 5 m" and "Sprint 10 m" independently of sex and growth spurt stage are observed in 12-year-old children [34-36]. However, the duration of the physical stimulus is still a controversial issue, as some studies have shown no major changes in the development of speed and other physical qualities in training programs lasting around 10 months [37]. Despite this, institutions such as the World Health Organization suggest moderate to vigorous physical activity for at least 60 minutes/day in elementary school students, while the theory of sports training has traditionally proposed the application of a physical training program for at least 3 months to achieve the generation of some degree of acute or chronic adaptation typical of sports training [38-40]. Following this line, the results of the control group could be partially explained according to the theory of sports training because of the principle of specificity, since the control group, being subjected to a training based on general exercises, could hardly have achieved the development of specific running speed compared to the experimental group subjected to a specific speed training [41,42].

5. Conclusions

An exercise program focused on speed development in children between 11 and 12 years of age can significantly improve the different manifestations of speed and, therefore, overall physical fitness along with sports performance, possibly attributing these results to acute and chronic adaptations generated by physical exercise and training loads, enhanced through the sensitive phase for speed development.

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