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Development of Physical Fitness Through Simulation Exercises for Ski Racers Aged 13-14. Non-Randomized Quasi-Experimental Study

Desarrollo de la condición física mediante ejercicios de simulación para corredores de esquí de 13-14 años. Estudio cuasi-experimental no aleatorizado

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Abstract

Introduction. In recent decades, the level of skiing performance in Russia has decreased significantly. This has necessitated problems with the preparation of athletes for competitions and the training process.

Objective. To analyze the effects of simulation training tools on the physical condition of ski racers aged 13–14 years.

Methods. Quasi-experimental, non-randomized study. 40 cross-country skiers aged 13–14 years belonging to the Korshik Village sports school (Russia) were assigned to a control ($n = 20$) and experimental ($n = 20$) group. Classes in the control group were conducted according to the usual training plan and in the experimental group simulation exercises were used. The control tests included pull-ups, squats, two-legged long jump, simulated 100-meter climbing and a 500-meter running test.

Results. The control group showed no significant improvements ($p > 0.05$), while the experimental group reported significant improvements in pull-ups (22.2%; $p< 0.05$), squat (5.9%; $p< 0.05$), two-legged long jump (6.8%; $p< 0.05$), 100-meter climbing simulation (7.8%; $p< 0.05$) and 500-meter run (4.2 %, $p <0.05$).

Conclusion. If, in the preparatory period, a series of simulation exercises are included in the training program for skiers aged 13–14 years, the level of physical fitness of athletes will improve significantly.

Declaration of interests
The authors have declared that there is no conflict of interest.

Data availability
All relevant data can be found in the article. For further information, please contact the corresponding author.

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Authors' contribution
Georgiy Polevoy: Conceptualization, data curation, formal analysis, fund acquisition, research, methodology, project management, resources, software, supervision, validation, visualization, writing: original draft, writing: review and editing.
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Keywords

Physical qualities; snow sports; physical fitness; simulated training; child.

Resumen

Introducción. En las últimas décadas, el nivel de rendimiento del esquí en Rusia ha disminuido significativamente. Esto ha generado problemas con la preparación de los atletas para las competiciones y el proceso de entrenamiento.

Objetivo. Analizar los efectos de herramientas de entrenamiento por simulación sobre la condición física de corredores de esquí de entre 13 y 14 años.

Métodos. Estudio cuasiexperimental, no aleatorizado. 40 esquiadores de fondo de entre 13 y 14 años pertenecientes a la escuela deportiva Korshik Village (Rusia) fueron asignados a un grupo control (n = 20) y experimental (n = 20). Las clases en el grupo de control se llevaron a cabo según el plan de entrenamiento habitual y en el grupo experimental se utilizaron ejercicios de simulación. Las pruebas de control incluyen dominadas, sentadillas, salto de longitud con dos piernas, escalada simulada de 100 metros y una prueba de carrera de 500 metros.

Resultados. El grupo control no presentó mejoras significativas ($p > 0,05$), mientras que el grupo experimental reportó mejoras significativas en pull-up (22,2%; $p < 0,05$), sentadilla (5,9%; $p < 0,05$), salto de longitud con dos piernas. (6,8%; $p < 0,05$), simulación de escalada de 100 metros (7,8%; $p < 0,05$) y carrera de 500 metros (4,2%, $p < 0,05$).

Conclusión. Si en el período preparatorio se incluye una serie de ejercicios de simulación en el programa de entrenamiento para esquiadores de 13 y 14 años, el nivel de condición física de los deportistas mejorará significativamente.

Palabras clave

Cualidades fisicas; deportes de nieve; aptitud física; entrenamiento simulado; niño.

Introduction

The Olympic Games usually reflect the highest level of sport achievements of the country, where the number of gold medals won by Russian skiers has been decreasing during the last 20 years, a product of the little flexibility presented by the Russian training model according to modern standards [1]. In this context, the achievements of cross-country skiing today are so great that without systematic training from an early age, it is impossible to achieve high performance at adult ages, with the process of sports training in young ski racers entailing various determinants of athletic performance [2–4].

Currently, the periodization of sports training, following the traditional classical model, postulates three phases for the annual performance of the sport, the first being oriented towards the acquisition of skills and sports qualities (preparatory period), the second to the maintenance and expression of the physical and psychological changes generated (competitive period) and the last one directed to the generation of a controlled loss of physical condition to generate an optimal recovery to restart the sports cycle (transition period) [5–7].

In this sense, the preparatory period is considered the most important during the macrocycle in skiers since, at this stage, the foundations of athletic performance expressed in the competitive period are laid, where the role of physical qualities is fundamental for the development of physical fitness and sports technique reflected on the movement on skis, being the dosage of the workload in the preparatory period of a ski racer determinant for athletic performance [8–10]. In this context, the exact choice of exercises during training will largely establish the effectiveness of physical workloads in the long term, as simulation exercises characterized by replicating motor skills are a primordial link for the development and learning of coordinate structures and sports performance variables at both specific and global levels [11,12], where the imitation of alternate two-step ascents with or without poles in combination with flat runs and descents are widely recognized as alternate elements that allow the establishment of routes with variants on the pattern of specialized walking, walking, jumping and running simulation [13–16].

In the same way, simulation exercises are often used during the beginning of the preparatory period to achieve settlement of the technical elements of sport, since the low volume and intensity of the workloads allow the development of physical qualities and motor skills that are determinant during the absence of snow in the summer [13–16]. In this sense, the analysis of bibliographic sources has shown that in skiing, physical fitness is crucial to achieve sporting results, while when simulation exercises are used, there is a positive transfer of physical qualities by assimilation of the technical elements resulting from the nature of the activity and motor skills [11–15]. A problem can be seen around the training of skiers in sports schools, whose solution seems to be related to the implementation of a set of exercises that can improve the training process in sports schools.

For this reason, the aim of this study was to analyze the effects of simulation training tools on physical fitness in ski racers aged 13–14 years.

Method

Design

Quasi-experimental, non-randomized study based on the ''Transparent Reporting of Evaluations with Non-randomised Designs'' [17]. The informed consent and research protocol were approved by the Research Committee of Vyatka University (Russia), with children being 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 [18].

Participants

The study was conducted at a sports school in the village of Korshik (Kirov, Russia). The experiment involved only children (boys) aged 13–14 years, cross-country skiers, who formed a control group (n = 20) and an experimental group (n = 20). Eligibility criteria were as follows:

Inclusion criteria:

- Children aged 13–14 attend the Korshik Village Sports School (Russia).
- Children who practice cross-country skiing regularly at least three times a 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 trainings or evaluations conducted in the classes taught at the Korshik Village Sports School (Russia).
- Children with acute or chronic illnesses that prevent them from participating in the experiment.

Intervention

The control group classes were conducted according to the usual training plan [19], while the experimental group was subjected to classes incorporating simulation exercises aimed at improving physical fitness in the preparatory period. These classes were conducted five days a week and in each class 20 or 90 minutes of the training session were allocated to the application of uniform and circular training methods. The intervention was divided into two stages:

From May to July 2022, the following simulation exercises were applied to develop endurance strength:

- Imitation of the hand movements of an alternating two-step run with a rubber buffer.
- Simulation of simultaneous hand movements in a single step with a rubber buffer.
- Simulation of simultaneous continuous running with a rubber buffer.
- Change the position of the legs with a load of 5 kg.
- Walking with resistance.

From August to November 2022, an emphasis was given to simulation exercises for the development of endurance and strength at high speed, including the following exercises:

- Jump on one leg, imitating the work of the hands, as in a two-step alternating run.
- Multiple jumps from foot to foot with strong and fast repulsion and flight.
- Simulation of jumping in a simultaneous one-step movement.
- Place the legs under the trunk and push with the supporting leg.
- Squat down on the supporting leg and push with the body moving sideways and forward.
- Simulation of the simultaneous movement of a step on the ground.
- Simulation of the simultaneous movement of two moving steps.
- Jumping: multiple jumps from one foot to the other, from side to side.
- Ski pole jumping simulation.
- Overcoming height through a jumping simulation with a two-step alternating movement with sticks.

The following methods were used to develop high-speed endurance:

- Variable method: 3–4 accelerations of 1 km. Climbs are overcome by a jumping imitation of a two-step alternating movement with sticks.
- Repeated method: repeated overcoming of climbs on different slopes by imitation of jumping with sticks.
- Repeated method: running 2-3 segments equal to 1/2 or 1/3 of the competitive distance with an intensity of 90–100% of maximum. Climbs are overcome by a jumping imitation of a two-step alternating movement with sticks. The rest between runs is at least 4–6 minutes.

Target

The aim of this work was to analyze the effects of simulation training tools on the physical condition of 13–14-year-old ski racers. For which, an alternative hypothesis that a set of simulation exercises applied contributes to improving the physical condition of 13–14-year-old skiers in the preparatory period was proposed.

Variables

Endurance strength was assessed using the pull-up and squat tests. The pull-up consisted of subjects being instructed to use an overhead grip with hands positioned slightly wider than shoulder-width apart, where each repetition would begin in a dead position (elbows extended, shoulders flexed and shoulder girdle elevated) with legs positioned behind the body, ankles crossed and knees bent. Once in the correct starting position, the subjects had to perform the concentric phase of the pull-up in an explosive manner, without swinging or kicking their legs. The concentric phase ended once the subject's chin passed the pull-up bar. Immediately after completing the concentric phase, subjects were instructed to perform the eccentric phase of lowering the body to the starting position at a comfortable speed, recording the maximum number of repetitions possible [20]. On the other hand, students were instructed to perform the maximum number of full squats for 1 minute, whose movement consisted of the subjects having to descend until the back of the thighs and calves made contact with each other or when the angle of the lumbar spine was equal to 0° [21].

Speed and endurance strength were assessed by the two-legged long jump test. This consisted of bending the knees while moving the arms forward and backward with a strong push, then jumping forward as far as possible, helping oneself with both arms and trying to land on the ground with feet together without losing balance to proceed to measure the distance performed [22].

The development of high-speed endurance was assessed by simulated 100-meter climbs and 500-meter run tests. The simulated 100-meter climb considered that standardized instructions were given for the 100-meter climb with 7 degrees of incline at the maximum possible speed to measure the time used in seconds [23]. The 500-meter run test considered that standardized instructions were given in the 500-meter run, where subjects were asked to run as fast as possible for 500 meters to measure the time in seconds [24].

Method of assignment

Each subject was assigned to an experimental group or to a control group in a non-probabilistic manner, this designation being made by pairing two groups of equivalent size. Thus, each group consisted of 20 children.

Unit of analysis

Groups of children were considered the lowest administrative unit used to evaluate the effects of the intervention. This consisted of a comparison of pull-ups, squats, long jump, simulated 100-meter, pull-up and a 500-meter sprint test.

Data analysis

The data were analyzed with IBM SPSS Statistics version 27.0 statistical software for the 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, the data being expressed through the descriptive data of central tendency and dispersion; mean and standard deviation. Differences between groups were determined with the Student's t-test for related samples, considering for all analyses the percentage frequency in addition to an alpha level of 0.05.

Results

Table 1 shows the analysis of the baseline data, which shows homogeneity between the control and experimental groups in the five indicators ($p > 0.05$).

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

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

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

Table 1. Baseline characteristics of the groups.

Indicators	Control Group $\bar{X}$ ± SD	Experimental Group $\bar{X}$ ± SD	t	p
Pull-ups (repetitions)	14,3 ± 1,08	15,8 ± 0,97	1,03	>0,05
Squats (repetitions)	60,3 ± 0,76	61,1 ± 0,97	0,65	>0,05
Standing long jump (cm)	212,3 ± 3,03	213,4 ± 4,33	0,21	>0,05
Simulation of a 100-meter climb (seconds)	25,8 ± 0,32	25,5 ± 0,54	0,48	>0,05
500-meter race simulation (seconds)	97,2 ± 0,65	97,3 ± 0,97	0,09	>0,05

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

Table 2. Comparison of physical fitness indicators in the control group (n = 20).

Indicators	Pre intervention $\bar{X}$ ± DS	Post intervention $\bar{X}$ ± SD	t	p
Pull-ups (repetitions)	14,3 ± 1,08	16,2 ± 0,77	1,43	>0,05
Squats (repetitions)	60,3 ± 0,76	62 ± 0,54	1,83	>0,05
Standing long jump (cm)	212,3 ± 3,03	218,2 ± 2,49	1,51	>0,05
Simulation of a 100-meter climb (seconds)	25,8 ± 0,32	25,1 ± 0,43	1,32	>0,05
500-meter race simulation (seconds)	97,2 ± 0,65	96,6 ± 0,86	0,56	>0,05

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

Table 3. Comparison of physical fitness indicators in the experimental group (n = 20).

Indicators	Pre intervention $\bar{X}$ ± DS	Post intervention $\bar{X}$ ± SD	t	p
Pull-ups (repetitions)	15,8 ± 0,97	19,3 ± 1,08	2,41	<0,05
Squats (repetitions)	61,1 ± 0,97	64,7 ± 0,87	2,77	<0,05
Standing long jump (cm)	213,4 ± 4,33	228 ± 2,7	2,86	<0,05
Simulation of a 100-meter climb (seconds)	25,5 ± 0,54	23,5 ± 0,43	2,9	<0,05
500-meter race simulation (seconds)	97,3 ± 0,97	93,2 ± 1,08	2,83	<0,05

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

Table 4. Comparison of physical fitness indicators in the control group (n = 20) and experimental group (n = 20) post intervention.

Indicators	Control group (n = 20) $\bar{X}$ ± SD	Experimental group (n = 20) $\bar{X}$ ± SD	t	p
Pull-ups (repetitions)	16,2 ± 0,77	19,3 ± 1,08	2,33	<0,05
Squats (repetitions)	62 ± 0,54	64,7 ± 0,87	2,57	<0,05
Standing long jump (cm)	218,2 ± 2,49	228 ± 2,7	2,67	<0,05
Simulation of a 100-meter climb (seconds)	25,1 ± 0,43	23,5 ± 0,43	2,67	<0,05
500-meter race simulation (seconds)	96,6 ± 0,86	93,2 ± 1,08	2,7	<0,05

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

Discussion

The simulation exercises incorporated in a sports training program for skiers aged 13 to 14 years produced significant improvements on the physical condition parameters, as expected by the planning methods and theory of sports training, since the program considered an adequate prescription of physical loads in terms of volume and intensity, in addition to an adequate duration for the generation of acute and chronic organic adaptations [8,11,25-27].

In this context, it is known that the behavior of coaches has always been oriented toward looking for ways to improve the training process, which is the multidisciplinary work key to obtaining improvements in athletic performance [11–14,23–28]. In general, we can observe that training proposals in skiing have been oriented toward the search for changes in standard training programs, emphasizing the specific training load together with the technical elements as fundamental links for injury prevention [4,29]. These data could indicate that, during a preparatory mesocycle in a traditional planning, improvements in physical qualities and sport biomechanics could be obtained through the incorporation of simulated exercises [5-8,30,31].

In this regard, the present work proposes to develop a series of simulation exercises aimed at improving physical fitness, with a set of simulated exercises oriented to the development of muscle strength fundamental for the modeling of body composition and the acquisition of oxygen consumption according to biological age and the needs of the sport [30-33]. Finally, these results suggest that a continuous pedagogical influence on athletes during the preparatory period should complement the search for positive results in the practical work in sports schools.

Conclusion

Simulation exercises incorporated into a sports training program for skiers aged 13 to 14 years can significantly improve the expression of basic physical qualities and, therefore, overall physical fitness and sports performance, being these results possibly attributed to the acute and chronic adaptations generated by the physical training load.

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