THE EFFECT OF TRAINABILITY ON THE PHYSICAL FITNESS OF YOUNG ATHLETES

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ABSTRACT

Athletic talent represents a high level of trainability in a certain type of sport. The earlier the level of trainability is identified, the more effective the sports training of the athlete will be. The aim of this study was to establish the effect of trainability on the physical fitness of adolescent athletes as a consequence of an applied training program adequate to the age and sports experience of the athletes. This study included 52 young athletes (24 boys and 28 girls), divided into 4 groups: male athletes from the control group (n = 10, mean age 14.88 ± 1.29 years), male athletes from the experimental group (n = 14, mean age 13.72 ± 1.15 years), female athletes from the control group (n = 14, mean age 15.69 ± 1.00 years), and female athletes from the experimental group (n = 14, mean age 13.41 ± 1.68 years). The experimental groups followed a specialized 12-week program signed for the purposes of the study. All participants completed the Alpha-Fit physical fitness test battery in addition to specific fitness tests before and after the training intervention. This study showed significant differences with larger effect sizes in nearly all components of health-related and specific physical fitness for the experimental groups after the training intervention in contrast to the control groups. The results of the standing long jump in the male (184.57 ± 19.79 cm vs 200.79 ± 20.01 cm, effect size = 0.8) and female athletes (179.07 ± 18.56 cm vs 183.93 ± 16.26 cm, effect size = 0.3) from the experimental groups showed significantly better values after the intervention, which indicated that strength is highly trainable for both genders at this age (13-14 years of age). The results of this study showed that the effect of trainability on physical fitness was greater for the athletes who were following the specialized training program based on the expected transfer of development in physical qualities.

Keywords: *athletes, physical fitness, trainability, field tests*

INTRODUCTION

Athletic talent is a complex phenomenon, which is widely considered in the scientific literature from methodological, biological, philosophical, and social point of view (Issurin, 2019). It represents a high level of trainability in a certain type of physical activity. In sports practice, trainability is studied based on the individual improvement of an athlete's achievement, as well as by using specific physical fitness tests criteria. The earlier the athletic talent is identified; the more effective the athlete's sports training can become. Trainability is considered to be a genetically transmitted trait of a person (Issurin, 2016), and it is mostly linked with the athletic talent of young athletes. Trainability is the ability of a living organism to change and adapt its structure and functions as a result of sports training (Hadjiev and Dasheva, 2010), and it can be categorized as: genetic inheritance; level of improvement in sports performance as a consequence of a specific training program; age and gender-related differences in terms of trainability. Morphological information, such as anthropometric and musculoskeletal data, physical fitness assessment, specific functional indicators, and psychological and social factors, are all used to evaluate trainability.

The terms “trainability” and “adaptation” have been used almost interchangeably in the coaching practice; however, there are some differences to consider.

Adaptation refers to the functional and morphological changes in the body as a result of a stimulus. Such changes include adaptation to strength, endurance, flexibility, and agility. Adaptation is genetically predetermined.

Trainability refers to the responsiveness of developing individuals, particularly to training stimuli, at different stages of growth and maturation, while also taking into account the genetic characteristics of adolescent athletes, as they respond individually, and adapt to a specific training stimulus (Balyi et al., 2013).

The analysis of the sports-pedagogical data shows that trainability as a process of adaptation is evident more effectively in athletes who develop in accordance with, or are a bit behind, their chronological age. The period between 12 and 16 years of age is characterized by enhanced individualization, harmonization, and gender differentiation (Harre, 1986), and any gaps in training and motor skills at this age would make it very difficult to be compensated in the next stages of human development. Girls complete their physical development at the age of 15-16, while boys continue their physical development until the age of 18-20. During this age period, and for the next few years after that, aerobic capacity and strength are highly trainable (Dick, 2007). After completing their physical development, adolescent athletes gradually approach their individual adaptive potential, as well as their best sports achievements in the chosen competitive discipline (Bonova, 2012; Bonova, 2020).

Models for long-term development of adolescent athletes have been developed in accordance with the sensitive periods of accelerated adaptation to training or training sessions. One such example is the Canadian system for the long-term athlete development. The system is based on the stages of human development and is focused on the specific motor qualities and the chosen sports discipline. According to this system, the most favorable age period for training in athletics is between 12 and 16 years of age for boys and between 11 and 15 years for girls. During this time, the rates of growth and development are the most intensive, and it is considered to be a sensitive period for the development of speed (Balyi et al., 2013). Furthermore, training for aerobic abilities and strength training can be introduced with a moderate to submaximal weight. Training in the main sport should be conducted and the development of lactate capabilities should be continued. Training in the main sport should be conducted 3-6 times a week, with duration of the training session of around two hours.

The first sensitive period for training speed is between 7 and 9, and the second one is between 11 and 13 years of age. Training for endurance is recommended to begin before puberty and to continue progressively throughout the period of intensive growth and development until the age of 16 (Balyi et al., 2013). Strength training is recommended to start after the intensive growth in height in girls, and 12-18 months after the intensive growth in height in boys (Bouchard et al., 1997).

The aim of this study was to accelerate the development of the motor qualities of adolescent athletes by applying an adequate methodology in the trainability periods. It should be noted that this was the first study on trainability in Bulgaria. Taking into consideration previous research in this field, a specialized 12-week training program was designed and applied to competitive adolescent athletes from athletics clubs in Bulgaria.

We hypothesized that the implementation of a training program designed in accord with the trainability periods would contribute to the improvement of the studied motor qualities.

METHODOLOGY

Participants

The study included 52 participants (24 boys and 28 girls), divided into 4 groups: male athletes from the control group (n = 10, mean age 14.88 ± 1.29 years), male athletes from the experimental group (n = 14, mean age 13.72 ± 1.15 years), female athletes from the control group (n = 14, mean age 15.69 ± 1.00 years), and female athletes from the experimental group (n = 14, mean age 13.41 ± 1.68 years). All participants were representatives of 4 athletics clubs from 4 major cities in Bulgaria (Sofia, Plovdiv, Blagoevgrad, and Vratsa). The inclusion criteria were as follows:

- to be 13 to 15 years of age;
- to be competitive athletes;
- to have a minimum of 2 years of sports experience in athletics;
- to conduct regular training practice – 3 to 5 sessions per week, with a duration of 2 hours each.

Institutional ethics approval for this study was granted by the National Sports Academy in Bulgaria, and informed consent was obtained from the parent/guardian of each participants, in accordance with the requirements of the Declaration of Helsinki for Human Research (WMA, 2013).

Design of the study

For the purposes of this study, a specialized 12-week training program was designed, based on established models and examples from the literature and the first author’s own considerable experience as a competitive athlete and an active coach. For ensuring relevant and comprehensive results, athletics clubs training competitive adolescent athletes in major cities of Bulgaria were contacted. Considering the fairly limited pool of potential subjects from the clubs who agreed to take part in the study, all who gave their consent to apply the training program or to provide data and serve as a control were included. In accordance with the consent granted, the study involved two control groups (boys and girls) and two experimental groups (boys and girls), as specified above.

The adolescent athletes from the control groups followed a traditional annual training program provided by their coaches. The program concentrated on the principal of separate training, in which the athletes trained mainly for a single specific physical quality (flexibility, strength, power, speed, endurance, balance, etc) during a training session.

The adolescent athletes from the experimental groups followed the specialized 12-week program (presented in Table 1 and 2) based on the expected transfer of development in physical qualities, i.e., when the development of one physical quality has a beneficial effect on another.

Table 1. *Training program for development of physical qualities in the adolescent athletes from the experimental groups in the period August – September*

Day of the week	Objectives	Training program
Monday	1.Development of the anaerobic alactic system 2. Development of muscular upper limbs strength. Intermittent training method was used	1. Warm-up: 1.1. 2 km jogging with HR of 150 bpm 1.2. General warm-up with a focus on flexibility development 1.3. Sprints - 8 x 20 m 1.4. Acceleration sprints 4 x 60 m 2. Main activities 2.1. Different types of sprint start - 8 x 20 m 2.2. 2 x 150 m with 90% of maximum speed 2.3. Strength exercises for the upper limbs performed by pairs, using a medicine ball. - standing chest pass - underhand throw - jump and throw the ball down the ground 3. Cool-down – 1 km jogging and stretching.
Tuesday	Development of anaerobic-aerobic system by using repeated training method	1. Warm-up – 2 km jogging with HR of 150 bpm 1.2. General warm-up 1.3. Running exercises - 8 x 30 m 1.4. Acceleration sprints 2 x 60 m 2. Main activities 2.1 Running exercises - 3x 200 m with 5 min rest (walking) - 600 m run for the 12-14-year-old athletes - 1000 m for the 15-16-year-old athletes (emphasis on the final acceleration) 3. Cool-down
Wednesday	Development of the aerobic capacity	1. Stretching 2. Main activities - 4-6 km run 3. Vertical jumps – 5 x 20 reps 4. Cool down – 1 km jogging and stretching
Thursday	Development of lower limb‘s muscle strength and strength-endurance	1. Warm-up – 2 km jogging with HR of 150 bpm 2. Main activities – Stair workout - Regular jump-ups (one stair at a time) – 3 x 20 reps - Regular jump-ups (two stairs at a time) – 3 x 10 reps - Left single-leg jump-ups (one stair at a time) – 3 x 10 reps - Right single-leg jump-ups (one stair at a time) – 3 x 10 reps - Running up the stairs – 3 sets - Running up the stairs (two stairs per step) – 3 sets 3. Cool down – 1 km jogging
Friday	Development of the aerobic-anaerobic system	1. Warm-up – 2 km jogging 1.1. General warm-up 1.2. Running exercises – 10 x 30 m 1.3. Acceleration sprints 2 x 60 m 2. Main activities – 1000 m alternating run (150 m with low speed, followed by 50 m with high speed) - Vertical jumps – 5 x 20 reps 3. Cool down – 1 km jogging

The main objective of the training on the first day of the micro-cycle (Mondays) was to develop the anaerobic alactic system by using the intermittent training method. On Tuesdays, the main objective was to develop the anaerobic-aerobic system of the athletes by using repeated training method, and on Wednesdays, the aim was to develop the aerobic capacity. On Tuesdays, the athletes worked on developing lower limb's muscle strength and strength-endurance, and on Fridays, the objective was to work on their aerobic-anaerobic system.

Table 2. *Training program for development of physical qualities in the adolescent athletes from the experimental groups in the period September - October*

Day of the week	Objectives	Training program
Monday	1. Development of the anaerobic alactic system 2. Development of muscular upper limbs strength. 3. Development of the aerobic capacity Intermittent training method was used Steady state run	1. Warm-up: 1.1. 2 km jogging with HR of 150 bpm 1.2. General warm-up with a focus on flexibility 1.3. Running exercises - 8 x 20 m 1.4. Acceleration sprints 4 x 60 m 2. Main activities 2.1. Low sprint start - 3 x 20 m, 2 x 30 m, 1 x 40 m, 1 x 50 m 2.2. Strength exercises for the upper limbs performed by pairs, using a medicine ball. - standing chest pass - underhand throw - jump and throw the ball down the ground 2.3. 1000 m steady state run with HR of 170-180 bpm 3. Cool-down – 1 km jogging and stretching.
Tuesday	1. Development of muscle strength-endurance 2. Development of the aerobic-anaerobic system	1. Warm-up – 2 km jogging with HR of 150 bpm 1.2. General warm-up 1.3. Running exercises - 6 x 30 m 2. Main activities 2.1 Strength-endurance: running uphill - 3 x 4 reps of 50 m (1-3 min rest of walking between the exercise and 5 min rest between the reps) - 1200 m alternating run 3. Cool-down - 1 km jogging
Wednesday	Development of the aerobic capacity	1. Warm-up 2. Steady state-run with HR of 160 bpm (30-50 min depending on the age of the athlete) 3. Vertical jumps – 3 x 20 reps 4. Cool down
Thursday		Rest day
Friday	Development of the aerobic capacity	1. Warm-up – 2 km jogging 1.1. General warm-up with a focus on flexibility 1.2. Hurdles drills 2. Main activities 2.1. 5 x 150 m with emphasis on the start in the first 50 m, and the finish in the last 50 m 2.2. Horizontal jumps 3 x 40 reps 3. Cool down – 1 km jogging

Saturday	Development of the aerobic-anaerobic system	1. Warm-up – 2 km jogging 1.1. General warm-up 1.2. Acceleration sprints 2 x 80 m 2. Main activities 2.1. 600 m run with 85% of max intensity, 7 min rest, followed by 3 x 300 m run 3. Cool down – 1 km jogging, and stretching

The proposed training program was designed taking into consideration the age, the sports experience and the level of sports training of the athletes. Thus, we were able to influence their development through the phenotypic factor which is part of the system of sports training.

The changes after the 12-week training program are a result related to the body's ability to be susceptible to the development of one or another quality as a consequence of inherited predispositions of the organism (i.e., the genotypic factor).

Body composition

Height was measured to an accuracy of within 0.1 cm by using a stadiometer, weight was measured with an electronic scale with an accuracy of 50 g, and body mass index (BMI) was calculated as:

BMI (kg/m^2) = Weight (kg) / Height (m)^2

Two skinfolds (triceps and subscapular) were measured by using the 'Lange Skinfold Caliper' within an accuracy of 1 mm. The percentage of body fat (BF%) was determined based on the two skinfolds, gender, race and age, by using the Slaughter's equations for adolescents (Slaughter et al., 1988). The lean body mass (LBM) was calculated as body weight (kg) – body fat (kg).

Physical fitness

The Alpha-Fit health-related physical fitness test battery (ALPHA, 2009) was applied to assess the physical fitness levels of the athletes. The tests included measurements for assessing body composition (height, weight, skinfolds), 20 m shuttle run tests (20 m SRT) to assess cardiorespiratory fitness and handgrip strength, standing long jump tests to assess musculoskeletal fitness, and 4 x 10 m shuttle run tests to assess motor fitness. The BeepShuttle Junior software (Kolimechkov et al., 2018, BeepShuttle Junior, 2021) with the original Leger's at al. protocol by Leger et al. (Leger et al., 1984) was applied to administer the 20 m SRT. The software calculates the maximal oxygen consumption (VO_2max in ml/kg/min) in accordance with the equations for adolescents, as proposed by Leger et al. (Leger et al., 1988).

The handgrip strength test was administered by using the TKK digital hand dynamometer (TKK 5101 Grip-D, Takey, Tokyo, Japan). The test was performed with an extended elbow, which had been shown to be the most appropriate protocol in order to evaluate maximal handgrip strength in children and adolescents (Espana-Romero et al., 2010, Kolimechkov et al., 2020). The average handgrip strength from both hands was used for the analyses. The relative handgrip strength was also calculated as: handgrip strength (kg) / body weight (kg).

The standing long jump test was performed on a non-slippery hard surface, and the test was recorded to an accuracy within 1 cm, by following the Alpha-Fit protocol (ALPHA, 2009). The test was performed twice, and the best attempt was used for the analyses.

The 4 x 10 m SRT at maximum speed was

performed in accordance with the Alpha-fit protocol, and the test was recorded in seconds by using a stopwatch to an accuracy of 0.1 sec.

Recently proposed percentile scores for the tests from the Alpha-Fit battery (Kolimechkov et al., 2019) which had been obtained by a linier interpolation from the existing norms (Miguel-Etayo et al., 2014, Ortega et al., 2011, Roriz De Oliveira et al., 2014, Tomkinson et al., 2016) were applied to assess the main components of physical fitness.

Specific physical fitness

The following tests were applied to assess the specific physical fitness of the athletes: 30 m sprint test, 600 m running test, and triple jump. The 30 m sprint test was performed twice from a standing position, and the better result was used for the analyses. The 600 m test was performed on a 400 m standard track and was recorded in seconds by using a stopwatch to an accuracy of 0.1 sec. The triple jump test was performed from a standing position (with three jumping phases). The first phase was a hop from a standstill with a landing on the preferred foot. The second phase was a long-stretched step with a landing on the opposite foot, and the last phase was the jump, where the athlete landed on both feet.

Statistical analyses

The statistical analyses were conducted with SPSS Statistics 26 software, using a Shapiro-Wilk test for normality, and descriptive statistics. Comparisons between the means of the parameters were performed for each group (before vs after the experiment). Comparisons between the control vs experimental groups were not performed due to the significant age differences of the participants in the groups. The Paired-Samples *T*-Test was used to compare the means of the parameters with normal distribution, the Wilcoxon signed-rank test – for those with abnormal distribution, and Cohen's *d* effect size was calculated to compare the effect of development in each physical fitness component. Statistically significant differences between the mean values were evaluated at $p < .05$, and all data in the text were presented as mean ± SD.

RESULTS

The anthropometric data in terms of age, height, weight, BMI, BF% and LBM of the female athletes from the control (n = 14) and the experimental (n = 14) groups are presented in Table 3 and Table 4.

Table 3. *Anthropometric data of the female athletes from the control group (n = 14) before and after the training intervention (mean ± SD)*

Group		Age [years]	Height [cm]	Weight [kg]	BMI [kg/m²]	BF% [%]	LBM [kg]
Control Group	Before	15.69 ± 1.00	165.57 ± 4.86	53.74 ± 5.87	19.60 ± 2.05	19.79 ± 4.67	42.94 ± 3.78
	After		166.43 ± 4.82**	54.90 ± 5.85*	19.85 ± 2.10	20.38 ± 4.75	43.56 ± 3.92*

* p <.05, ** p <.01

Table 4. *Anthropometric data of the female athletes from the experimental group (n = 14) before and after the training intervention (mean ± SD)*

Group		Age [years]	Height [cm]	Weight [kg]	BMI [kg/m²]	BF% [%]	LBM [kg]
Experimental Group	Before	13.41 ± 1.68	157.82 ±8.79	48.28 ± 9.06	19.21 ± 2.21	21.06 ± 4.43	37.82 ± 5.71
	After		159.32 ±8.22**	49.47 ± 8.78***	19.34 ± 2.10	20.64 ± 4.58	38.96 ± 5.36***

** $p < .01$, *** $p < .001$

The anthropometric data in terms of age, height, weight, BMI, BF%, and LBM of the male athletes from the control (n = 10) and the experimental (n = 14) groups are presented in Table 5 and Table 6.

Table 5. *Anthropometric data of the male athletes from the control group (n = 10) before and after the training intervention (mean ± SD)*

Group		Age [years]	Height [cm]	Weight [kg]	BMI [kg/m²]	BF% [%]	LBM [kg]
Control Group	Before	14.88 ± 1.29	170.1 ± 7.07	58.8 ± 11.97	20.17 ± 2.97	11.85 ± 4.57	51.53 ± 9.30
	After		171.8 ± 6.78***	59.4 ± 11.12	20.00 ± 2.79	11.80 ± 4.20	52.16 ± 9.11

*** $p < .001$

Table 6. *Anthropometric data of the male athletes from the experimental group (n = 14) before and after the training intervention (mean ± SD)*

Group		Age [years]	Height [cm]	Weight [kg]	BMI [kg/m²]	BF% [%]	LBM [kg]
Experimental Group	Before	13.72 ± 1.15	163.4 ± 12.51	51.2 ± 12.12	19.00 ± 2.90	16.14 ± 6.46	42.74 ± 9.66
	After		165.5 ± 12.29***	52.7 ± 12.04*	19.05 ± 2.81	16.06 ± 6.60	43.99 ± 9.55*

* $p < .05$, *** $p < .001$

The results showed increased values of height and weight in both groups after conducting the experiment, which is a logical consequence of their normal physical development. No statistical differences were observed regarding BMI and percentage of body fat (BF%). The experimental groups had significantly higher values of lean body mass in girls (37.82 ± 5.71 kg before vs 38.96 ± 5.36 kg after the experiment, Table 4), and in boys (42.74 ± 9.66 kg before vs 43.99 ± 9.55 kg after the experiment, Table 6).

The results from the musculoskeletal, motor, and cardiorespiratory fitness assessment of the female athletes are presented in Table 7 and Table 8, and those of the male athletes – in Table 9 and Table 10. The female athletes from the control group showed a significant decrease in their lower body strength (206.86 ± 25.99 cm vs 202.71 ± 29.21 cm after the experiment). There were no significant differences in their results in terms of the upper-body strength, motor, and cardiorespiratory fitness (Table 7).

The female athletes from the experimental group showed significantly higher absolute values (179.07 ± 18.56 cm before vs 183.93 ± 16.26 cm after the experiment, effect size = 0.3) of the explosive lower body strength assessed by the standing long jump test (Table 8). The absolute value and the percentile score of their motor fitness assessed by the 4 x 10 m SRT were also significantly better after the training intervention (11.49 ± 0.41 sec vs 11.10 ± 0.39 sec, effect size = 0.7).

Table 7. *Musculoskeletal, motor, and cardiorespiratory fitness assessment of the female athletes from the control group (n = 14) before and after the training intervention (mean ± SD)*

Group		Musculoskeletal Fitness				Motor Fitness		Aerobic Fitness	
		Grip Force [kg]	Grip Force PRs score	Long jump [cm]	Long jump PRs score	4x10m SRT [sec]	4x10m SRT PRs score	VO_2max [ml/kg/min]	VO_2max PRs score
Control Group	Before	23.25 ± 4.31	29.77 ± 26.54	206.86 ± 25.99	94.91 ± 7.64	10.55 ± 0.73	93.48 ± 6.52	49.36 ± 4.44	76.99 ± 27.23
	After	23.81 ± 4.13	31.05 ± 26.52	202.71* ± 29.21	92.64 ± 12.02	10.80 ± 0.77	90.13 ± 11.66	49.27 ± 3.86	75.94 ± 27.38

* $p < .05$

Table 8. *Musculoskeletal, motor, and cardiorespiratory fitness assessment of the female athletes from the experimental group (n = 14) before and after the training intervention (mean ± SD)*

Group		Musculoskeletal Fitness				Motor Fitness		Aerobic Fitness	
		Grip Force [kg]	Grip Force PRs score	Long jump [cm]	Long jump PRs score	4x10m SRT [sec]	4x10m SRT PRs score	VO_2max [ml/kg/min]	VO_2max PRs score
Experimental Group	Before	22.73 ± 4.75	45.77 ± 26.30	179.07 ± 18.56	89.61 ± 9.79	11.49 ± 0.41	88.26 ± 5.96	53.21 ± 5.17	88.86 ± 22.39
	After	23.76 ± 5.40	49.00 ± 26.95	183.93* ± 16.26	92.06 ± 7.84	11.10** ± 0.39	92.24** ± 5.29	52.88 ± 4.71	89.96 ± 16.48

* $p < .05$, ** $p < .01$

The male athletes from the control group showed significantly higher results with regards to their lower body strength, motor, and cardiorespiratory fitness (effect size = 0.3, Table 9). The male athletes from the experimental group also showed significantly higher results, but with a larger effect size. The absolute value of the standing long jump test (184.57 ± 19.79 cm before vs 200.79 ± 20.01 cm after the experiment, effect size = 0.8) and its percentile score (71.29 ± 22.83 vs 78.80 ± 19.57) were both significantly higher after the training intervention in the boys from the experimental group (Table 10). The absolute value of their isometric upper-body strength assessed by the handgrip strength test was also significantly higher (26.57 ± 8.30 kg vs 29.16 ± 9.41 kg, effect size = 0.3). The absolute value of the 4 x 10 m SRT (11.09 ± 0.61 sec vs 10.65 ± 0.67 sec) and its percentile score were both significantly better after the training intervention (effect size = 0.7).

Table 9. *Musculoskeletal, motor, and cardiorespiratory fitness assessment of the male athletes from the control group (n = 10) before and after the training intervention (mean ± SD).*

Group		Musculoskeletal Fitness				Motor Fitness		Aerobic Fitness	
		Grip Force [kg]	Grip Force PRs score	Long jump [cm]	Long jump PRs score	4x10m SRT [sec]	4x10m SRT PRs score	VO_2max [ml/kg/min]	VO_2max PRs score
Control Group	Before	30.60 ± 9.15	33.78 ± 38.44	210.70 ± 23.37	76.70 ± 19.90	10.77 ± 0.39	76.52 ± 14.45	51.61 ± 3.08	78.68 ± 16.30
	After	30.83 ± 7.92	29.68 ± 29.48	219.40* ± 17.31	83.79 ± 11.14	10.52** ± 0.36	82.54* ± 9.63	53.46* ± 3.53	86.36* ± 15.48

* $p < .05$, ** $p < .01$

Table 10. *Musculoskeletal, motor, and cardiorespiratory fitness assessment of the male athletes from the experimental group (n = 14) before and after the training intervention (mean ± SD).*

Group		Musculoskeletal Fitness				Motor Fitness		Aerobic Fitness	
		Grip Force [kg]	Grip Force PRs score	Long jump [cm]	Long jump PRs score	4x10m SRT [sec]	4x10m SRT PRs score	VO_2max [ml/kg/min]	VO_2max PRs score
Experimental Group	Before	26.57 ± 8.30	34.16 ± 29.26	184.57 ± 19.79	71.29 ± 22.83	11.09 ± 0.61	75.72 ± 19.26	54.73 ± 4.23	89.33 ± 19.06
	After	29.16** ± 9.41	37.63 ± 30.77	200.79** ± 20.01	78.80** ± 19.57	10.65*** ± 0.67	81.84** ± 14.88	54.75 ± 3.90	90.41 ± 15.76

** $p < .01$, *** $p < .001$

The results from the specific physical fitness assessment of the female athletes are presented in Table 11 and Table 12, and those of the male athletes – in Table 13 and Table 14. While the female and male athletes from the control groups showed significantly better results in the 30 m sprint (effect size = 0.4) and 600 m run tests (effect size = 0.2), those from the experimental groups (Table 12 for girls and Table 14 for boys) had significantly better values after the training intervention in all three specific tests with larger effect sizes (0.7 and 0.5 respectively).

Table 11. *Specific physical fitness assessment of the female athletes from the control group (n = 14) before and after the training intervention (mean ± SD)*

Group		30 m [sec]	600 m [sec]	Triple Jump [m]
Control Group	Before	4.37 ± 0.26	120.0 ± 7.80	6.55 ± 0.33
	After	4.33 ± 0.23*	119.0 ± 7.39**	6.55 ± 0.35

* $p < .05$, ** $p < .01$

Table 12. *Specific physical fitness assessment of the female athletes from the experimental group (n = 14) before and after the training intervention (mean ± SD)*

Group		30 m [sec]	600 m [sec]	Triple Jump [m]
Experimental Group	Before	4.92 ± 0.29	137.6 ± 9.56	5.61 ± 0.44
	After	4.81 ± 0.28***	132.9 ± 11.86*	5.87 ± 0.48**

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 13. *Specific physical fitness assessment of the male athletes from the control group (n = 10) before and after the training intervention (mean ± SD).*

Group		30 m [sec]	600 m [sec]	Triple Jump [m]
Control Group	Before	4.45 ± 0.51	116.5 ± 11.28	6.81 ± 0.87
	After	4.29 ± 0.40*	114.2 ± 10.71***	6.97 ± 0.67

* $p < .05$, *** $p < .001$

Table 14. *Specific physical fitness assessment of the male athletes from the experimental group (n = 14) before and after the training intervention (mean ± SD)*

Group		30 m [sec]	600 m [sec]	Triple Jump [m]
Experimental Group	Before	4.82 ± 0.29	123.5 ± 12.74	5.68 ± 0.53
	After	4.63 ± 0.30***	119.3 ± 11.22***	6.03 ± 0.58***

*** $p < .001$

The 30 m sprint test showed significantly better results in the experimental groups (4.92 ± 0.29 sec vs 4.81 ± 0.28 sec after the training intervention in girls; 4.82 ± 0.29 sec vs 4.63 ± 0.30 sec in boys, effect size = 0.7). The results from the triple jump in the experimental groups were also significantly higher after the training intervention for both, female and male athletes (Table 12 and Table 14). In contrast, the results in the control groups showed no significant differences in the triple jump test.

DISCUSSION

The Alpha-Fit physical fitness test battery (ALPHA, 2009), as well as the applied specific fitness tests for athletes (30 m sprint, 600 m run and triple jump tests), provided a good methodology for comparing the rates of trainability within different components and health-related fitness levels before and after the training intervention in this study. The application of those tests can also be used as a valid and reliable assessment of physical fitness in children and adolescents from different countries around the world based on the age- and gender-specific international norms.

The mean BMI and BF% values were within the normal limits in all four groups from our study (Tables 3 - 6). Only one boy was assessed as overweight according to his BMI (BMI = 26.0 kg/m^2; BF% = 34.1%). Overall, the athletes showed 'very good' mean percentile scores (PRs > 75) in all fitness tests, except handgrip strength (the mean PRs in grip strength was between 29 and 49 depending on the group). About 67% of the athletes in this study scored below the 50th handgrip strength percentile for their age. This was probably due to the low body weight of the athletes (mean BMI was close to the lower normal limits ranging between 19.6 and 20.1 kg/m^2) and the nature of the grip test, which takes into consideration only the absolute strength. Therefore, the evaluation of grip strength might be better assessed by using relative parameters, such as the relative handgrip strength (handgrip strength in kg / body weight in kg), because the workload in athletics comes mainly from the athlete's body weight. However, relative grip strength norms for children and adolescents are still not available in the literature and should be obtained in future research.

This study showed significant differences with larger effect sizes in nearly all components of health-related and specific physical fitness for the experimental groups after the training intervention, compared to the control groups. The results of the strength parameters in the male and female athletes from the experimental groups showed significantly better values after the intervention, which indicated that strength is highly trainable in both sexes at this age (13-14 years of age). The male athletes demonstrated a higher rate of trainability in this component. It should be noted that according to Ford et al, "Strength increases in both boys and girls until about the age of 14, when it begins to plateau in girls and a spurt is evident in boys" (Ford et al., 2011).

The results of the speed parameters showed that 13-14 years of age fall within the sensitive period for improving motor fitness and speed (Tables 7-14). These results are in line with established models for long-term development of adolescent athletes, according to which there are two "windows of opportunity" potentially maximizing training gains in childhood: the first appearing at approximately 7–9 years in both boys and girls, and the second – between 11 and 13 years in girls and between 13 and 15 years in boys (Ford et al., 2011). The results of this study also confirm the observations from our previous study on trainability of adolescent Bulgarian hockey players (Bonova, 2020). In the present study, while males and females from the experimental groups showed significant improvement after the intervention, the male athletes had a higher rate of trainability in the 30 m sprint test in comparison to the female athletes. On the other hand, the female athletes showed a higher rate of trainability (large vs medium effect size) in the 4 x 10 m SRT, which is probably due to the coordination and agility needed for the optimal performance of the test. The control groups also showed better results after the experiment but with a lower rate of trainability.

The results of the aerobic fitness, assessed by the 20 m SRT, showed significant differences only in the male athletes from the control group after the experiment. However, the boys from this group were on average 1.2 years older. All four groups showed significantly higher values in the 600 m running test after the training intervention, which is probably because of the specific nature of that test, regarding the training process in adolescent athletes. The 600 m running discipline is one of the disciplines in athletics for children between the ages of 12 and 14, and it is often performed in the training of athletes. Our findings are in line with the observations of Jones, et al. who conducted a 9-month study in 2019 and established large effect sizes for improvement in variables such as 600 m performance, VO_2 max, and critical speed (Jones, et al., 2019).

There are various models for the development of athletes' talent reported in the scientific literature. A number of findings suggest that "the characteristics of the training method may influence the effectiveness of training during potential sensitive periods, potentially making training less effective when a method with less favorable training characteristics is used" (Van Hooren & Croix, 2020). Models are often based on growth development and rates in specific criteria, such as the Differentiated Model of Giftedness and Talent, DMGT (Gagne, 2008). Gagne describes the developmental processes in three different forms: maturation (process largely controlled by the genetic endowment), spontaneous learning (knowledge and skills acquired as part of daily activities), and systematic learning (not only by a conscious intention to attain specific learning tasks, but also by a systematically planned sequence of learning steps to achieve these tasks) (Gagne, 2008). Physical fitness and abilities are of particular importance for development of athletes' talent. Measuring and assessing health-related and specific physical fitness can provide important information about the athlete's trainability, physical development, and physical fitness. It can be also used to evaluate specific training intervention, such as the one applied in our study, and it can help predict the progress from adolescence into adulthood. Physical trainability among adolescents is crucial to optimize training with a view for long-term development (Norjali Wazir & Ramli, 2021).

It is yet to be determined whether the use of such training tools during sensitive periods would contribute to maintaining the achieved motor skill trainability rates in adulthood. Only a longitudinal study of the same subjects may provide an answer. It should also be noted that the scope of the study was limited only to athletes from Bulgarian clubs who consented to participate, and it would be highly beneficial to conduct further studies on a larger scale with a larger number of subjects. However, it is also noteworthy that this research was the first study on trainability conducted in Bulgaria and we believe that our 12-week program may be further developed and successfully applied by other coaches and athletes in future.

CONCLUSION

We believe that the use of age-appropriate training tools helps to increase the rate of motor skill trainability during the period of sensitive age periods. Missing an appropriate amount of training during these age periods will inevitably make it difficult for athletes and coaches to develop those skills in the next stages of sports development. The participants in this study were within the sensitive age periods for improving physical fitness in young athletes. The effect of trainability on physical fitness was found to be greater for the athletes who followed the proposed 12-week program based on the expected transfer of development in physical qualities.

The highest rates of trainability were observed in the tests for specific physical capacity in the experimental groups (girls aged 13.4 and boys aged 13.7 years). In our opinion, this is due to the specific training program to which the athletes were subjected. In the control groups, only some of the tests showed similar trends, but with a weaker size effect.

The tests examining the rate of trainability of musculoskeletal and motor fitness also showed high and statistically significant data in the experimental groups (girls aged 13.4 and boys aged 13.7 years). The control groups (girls aged 15.6 and boys aged 14.9 years) showed partial improvement of individual motor skills – strength of the lower limbs and agility, but with weaker size effect (i.e. lower rate of trainability).

The results of the aerobic fitness, assessed by the 20 m SRT, showed significant differences only in the male athletes from the control group after the experiment. However, the boys from this group were on average 1.2 years older than those in the experimental group. In the experimental groups there was no change in the rate of aerobic capacity training. This may be due to different factors – on the one hand, the age of the participants may not be sensitive regarding that quality, and on the other hand, endurance training is defined as a strictly individual ability of the body requiring athletes who are capable responders.

We can conclude that in the studied sample aged 13-15 years, the trainable motor qualities are explosive power of the lower limbs, speed of movement and agility. Further research on a larger scale would also help to fully determine and potentially optimize the benefits from the proposed training program.

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