

Balancing physical development and health in adolescents through controlled High-Intensity Training

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Considering the growing interest in high-intensity training (HIT) among the youth, it is crucial to explore its impact not only on improving physical fitness but also on the overall health of adolescents. The aim of this study was to assess how HIT can contribute to the development of physical qualities in adolescents while minimizing the risks of excessive strain.

Material and Methods The study encompassed 28 students (14±0.9 years) from a lyceum in Kharkiv, Ukraine. The participants were divided into a control group (CG, n=14; including boys - n=7 and girls n=7) and an experimental group (EG, n=14; including boys - n=7 and girls n=7). The EG participated in high-intensity training sessions twice a week, with each session lasting 20 minutes. The program's effectiveness was evaluated using a series of physical ability tests. PyCharm Community Edition integrated development environment was used for the analysis and visualization of the obtained data. The software code was written in Python. The experiment was conducted in Kharkiv (Ukraine), located in a war zone since February 2022. The requirements of the military administration for ensuring the safety of experiment participants were observed.

Results After the training program, boys from the EG showed improvement in tests on speed, coordination, and motor skills ($p<0.05$). Girls in the EG demonstrated significant improvement in the "Sit-up from a sitting position in 30 seconds" test ($p<0.05$), as well as improvements in speed and coordination tests.

Conclusions High-intensity workouts can be effectively integrated into the physical education program for teenagers, provided that caution is exercised and the workload is monitored. The results confirm that such an approach contributes to the development of physical qualities and supports the health of teenagers. This suggests a nuanced understanding of how such programs can be optimized for different genders to enhance physical education outcomes.

Keywords: high-intensity training, physical abilities, teenagers, physical education, health

Introduction

In the context of modern youth physical culture and sports, high-intensity training (HIT) holds a special place. Such workouts attract attention with their ability to quickly improve physical fitness. However, it's critically important not only to aim for enhancing teenagers' physical preparedness but also to ensure safety and health during their training sessions. This approach sets the stage for a nuanced discussion on the benefits and challenges of incorporating high-intensity training into youth physical education, emphasizing the importance of a balanced approach to maximize benefits while ensuring the well-being of participants.

Research on high-intensity training (HIT) and its role in the physical development and health of adolescents highlights their potential and challenges [1, 2, 3, 4, 5]. Cano et al. [6] revealed that protocols of high-intensity interval training with sprint running can significantly improve aerobic performance in

male rugby players aged 15-16 years. The authors point out the importance of HIT in sports training. Faelli et al. [7] demonstrate that integrating HIT into traditional rowing programs can positively affect the physiological responses and internal workload of teenage rowers. This underscores the effectiveness of this approach across a variety of sports disciplines.

At the same time, Harris et al. [8] focus on the psychological aspects of HIT. The authors note that HIT in socio-economically less advantaged did not affect the self-esteem and psychological well-being of adolescents. They also discuss issues of sociocultural adaptation and the effectiveness of such approaches. Hsieh et al. [9] highlight the positive impact of HIIT on cognitive functions, including inhibition and working memory in children and adolescents. Such results broaden the understanding of the impact of physical activity on brain function.

Oliveira et al. [10] investigate the physiological mechanisms underlying HIT. The authors note an

improvement in baroreflex sensitivity in healthy adolescents. This may have long-term beneficial effects on the cardiovascular system. Poon et al. [11] extend the application of HIT to children and adolescents with special educational needs. The authors found improvements in body composition, physical fitness, and cardiometabolic biomarkers, as well as in mental health and cognitive functions of participants. This highlights the versatility and effectiveness of HIT.

Racil et al. [12] and Sarkar et al. [13] confirm the long-term benefits of HIT for adolescents with obesity and the positive impact of vitamin intake on physiological indicators. The authors highlight the importance of supportive interventions. Weston et al. [14] investigate the practical application of HIT in a school setting. The authors identified the potential of personalized approaches and variability in exercises to improve engagement and outcomes.

Thus, the aggregate of research data underscores the significance of HIT in the development of physical fitness and health in adolescents. This points to the need for a harmonious balance between the intensity of workouts and their safety, as well as the potential for individualization and adaptation of programs to maximize positive impact.

This study is aimed at identifying the optimal conditions for implementing high-intensity training in physical education programs for adolescents in the context of developing their physical qualities while simultaneously reducing the risk of excessive loads. This approach involves careful monitoring and adaptation of training loads, making this work an important step towards creating more health-preserving and safe sports programs for youth.

Materials and Methods

Participants

The study involved 28 students (14 ± 0.9 years) from a lyceum in Kharkiv, Ukraine. The participants were divided into a control group (CG, $n=14$; including boys - $n=7$ and girls $n=7$) and an experimental group (EG, $n=14$; including boys - $n=7$ and girls $n=7$). Parents consented to their children's participation in the experiment. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University. Special Conditions of the Experiment

The experiment was conducted in Kharkiv (Ukraine), located in a war zone since February 2022. The requirements of the military administration for ensuring the safety of the experiment participants were observed. Participants were informed about specific actions to take during the announcement of alarm signals in the city (loud siren sounds and a message on the mobile phone) and had already acquired practical skills for such actions.

Study Design

The EG participated in high-intensity training sessions twice a week, with each session lasting 20 minutes. To determine the level of development of the students' physical abilities, the following tests were selected:

- Test 1. Cadence Push-Up Test, number of times in 30 sec.;
- Test 2. Eurofit Sit Up Test (for 30 sec.), number of times;
- Test 3. Standing long jump (cm);
- Test 4. 1000 m running (min, s);
- Test 5. 30m Sprint Test, sec.;
- Test 6. Running in place. Three attempts are given. The maximum frequency of leg movements within 5 seconds is assessed.
- Test 7. Standing Forward Bend (standing on a bench). The distance to which a student can bend their torso forward, with legs apart and without bending the knees, is assessed. It is measured in centimeters from the fingertips.
- Test 8. Exercise with a gymnastic stick (cm) [15]. The outcome with which a student can rotate their hands forward and backward, holding the stick with both hands, without changing the grip on the stick and without bending the elbows, is assessed. It is measured in centimeters.
- Test 9. Test 7 "Ruler Drop Test", cm [16, 17]; The test is repeated 3 times. The minimum value of the indicator in centimeters is considered.
- Test 10. Shuttle run (4×9 m).

Statistical Analysis

For the analysis and visualization of the obtained data, the integrated development environment PyCharm Community Edition was used. The programming code was written in Python, with a primary focus on using the Matplotlib library for creating graphs and diagrams. The NumPy library was used for processing statistical data, including the calculation of mean values, standard deviations, and determining the statistical significance of results. Differences were considered significant at a significance level of $p < 0.05$.

Results

The study aimed to evaluate the dynamics of changes in the physical ability indicators of adolescents under the influence of training programs in the control (CG) and experimental (EG) groups. The results obtained through specially selected tests for boys are presented in Figure 1.

The analysis of data from Figure 1 shows that by the end of the experiment, there was a tendency for improvement in the physical ability indicators in both groups. This is particularly true for the increase in the maximum movement frequency in 5 seconds and the improvement in the flexibility test (test 8), where a statistically significant growth was recorded in the experimental group. There is also noticeable

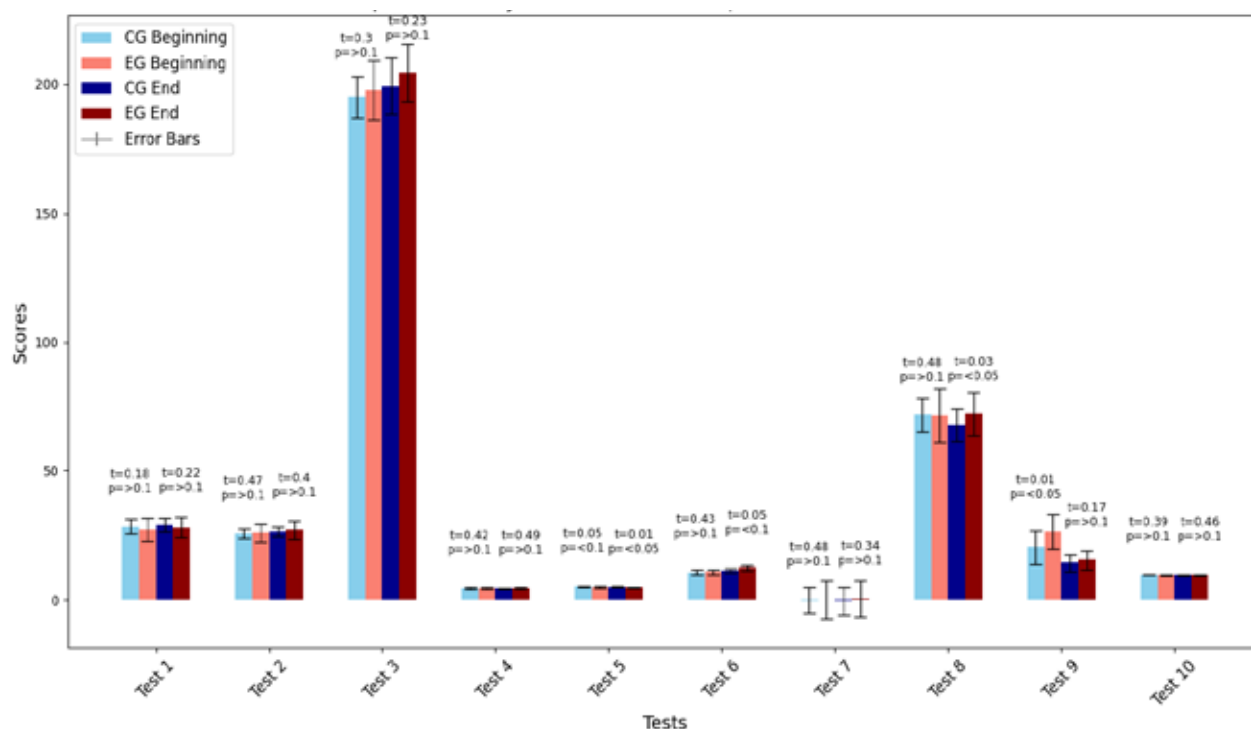


Figure 1. Comparison of the dynamics of physical abilities development between CG (Control Group) and EG (Experimental Group). Boys (n=14)

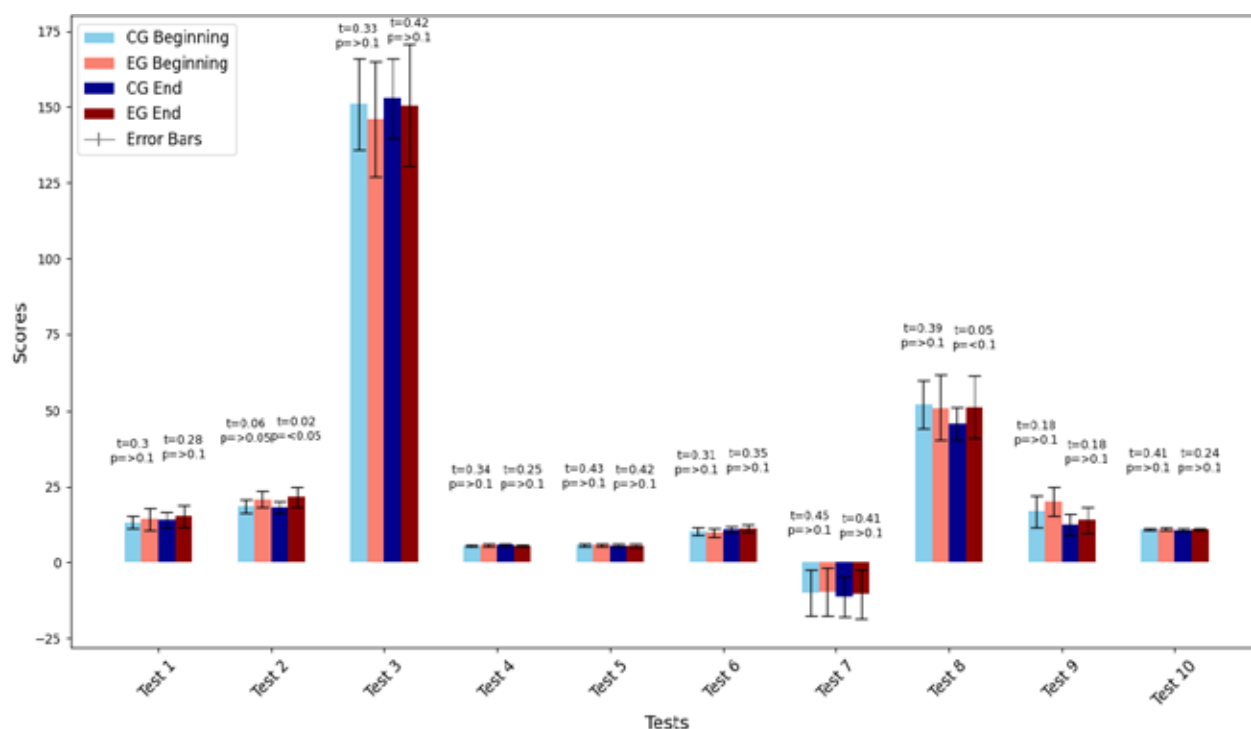


Figure 2. Comparison of the dynamics of physical abilities development between CG (Control Group) and EG (Experimental Group). Girls (n=14)

improvement in test 5 compared to the beginning of the experiment, indicating a positive impact of the training process on some aspects of the boys' physical preparedness. It is important to note that significant changes in the level of physical preparedness are not observed in all tests, highlighting the need for further research to optimize training programs.

To evaluate the impact of training programs

on the development of physical abilities in girls, a study comparing the dynamics between the control group (CG) and the experimental group (EG) was conducted. The study included various tests, the results of which were recorded at the beginning of the experiment (December 2022) and at the end of the experiment (May-July 2023). The data are presented in Figure 2.

The analysis of the data presented in Figure 2 demonstrates that by the end of the experiment, a statistically significant increase in the number of actions performed in 30 seconds was observed in the experimental group compared to the control group. This indicates an improvement in overall physical fitness and endurance among girls participating in the experimental program. In other tests, no statistically significant differences between the groups were found, which may indicate a similar level of progress in the development of other physical qualities. Special attention should be given to test 8, where a tendency towards improved indicators in the EG by the end of the study was also observed, suggesting a positive impact of the training process on the flexibility of the participants.

Discussion

In our study, we analyze the impact of high-intensity training (HIT) on the physical development of adolescents, minimizing health risks. The results from Figure 1 show improvement in maximum movement frequency and flexibility (test 8) in the experimental group, confirming the positive impact of HIT. However, not all tests showed significant changes, highlighting the need for further research to optimize training programs. The analysis of Figure 2 revealed an improvement in endurance among girls in the experimental group, indicating an increase in overall physical fitness. The absence of differences in some other tests suggests equal progress in the development of various physical qualities between groups, requiring more detailed analysis in the future. These results underscore the importance of HIT for improving the physical abilities of adolescents. They also highlight the necessity of balancing the intensity of training with ensuring the safety and health of participants.

Our study confirmed the positive impact of high-intensity interval training (HIT) on the physical fitness of adolescents, similar to the results of Cano et al. [6] and Faelli et al. [7]. In this context, there is consistency with these and other findings [5, 18, 19] regarding the improvement of aerobic performance and physiological indicators in adolescents.

At the same time, the results of Harris et al. [8] and Wassenaar et al. [4] emphasize that HIT did not have a significant impact on mental health

and self-esteem in adolescents. This indicates possible differences in the effects of HIT depending on the context of its implementation and the targeted assessment indicators. It reminds us of the importance of considering socio-economic and cultural factors when planning and evaluating the effectiveness of training programs.

Hsieh et al. [9] and Poon et al. [11] demonstrate the positive impact of HIT on cognitive functions and the health of children and adolescents with special educational needs. These results support our observation of improved physical fitness. This data and other studies [2, 3, 20] confirm the multifaceted positive impact of HIT, covering not only physical but also cognitive and psychological aspects of health.

The study by Oliveira et al. [10] highlights the importance of improving baroreflex sensitivity through HIT. This complements our findings of statistically significant improvements in the flexibility test and overall physical fitness. It emphasizes the importance of including a variety of assessment metrics when investigating the effects of training to obtain a comprehensive picture of HIT's impact.

In conclusion, comparing our results with data from other studies confirms the positive impact of HIT on the physical development of adolescents. At the same time, it points to the need for further research to optimize training programs, taking into account individual and group differences. This opens the way to more personalized approaches in physical training, contributing to improved physical fitness and the overall well-being of adolescents.

Conclusions

High-intensity training is an effective means of improving the physical fitness of adolescents, especially in terms of speed-strength qualities and flexibility. However, the results also highlight the need for individualization and careful planning of training programs to minimize risks and take into account the individual characteristics of participants. It is important to continue research in this area to determine the optimal training parameters. In the future, this could lead to the development of more effective and safe methods of physical training for youth.

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Cite this article as:

Lazarev S, Kryventsova I, Lutskyi V. Balancing physical development and health in adolescents through controlled High-Intensity Training *Pedagogy of Health*, 2024;3(1):31–36.
<https://doi.org/10.15561/health.2024.0105>

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Received: 12.04.2024

Accepted: 15.05.2024; Published: 30.06.2024