



Effects of an 8-Week Physical Education Training Program on Physical Fitness in U17–U18 Students

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

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Accepted for Publication: April 6, 2026

Published: May 30, 2026

DOI: 10.17309/tmfv.2026.3.08

Abstract

Objective. The effectiveness of physical education programs often varies because the specific contribution of exercise sequencing and load progression to fitness outcomes remains insufficiently understood. This study examined how deliberate control of exercise order and progressive load distribution in an 8-week program affects speed, agility, explosive power, and endurance in U17–U18 students.

Materials and Methods. Fifty male students aged 17–18 years were randomly assigned to an experimental group (n = 25) and a control group (n = 25). The experimental group completed the structured program three times per week for eight weeks. Physical fitness was assessed using the 30-m sprint, Illinois agility test, standing long jump, and Cooper 12-minute run test.

Results. The experimental group showed statistically significant improvements in all four parameters (p < 0.05), with large effect sizes (Cohen's d = 0.83–1.10), whereas the control group showed no significant changes.

Conclusions. The improvements resulted from the sequencing in which speed and agility drills preceded explosive strength exercises, while endurance activities concluded each session, together with progressive load distribution across three microcycles. When this specific order and load progression are followed, substantial gains across multiple fitness components can occur simultaneously. These findings demonstrate that deliberate changes in exercise sequencing and load parameters can influence the magnitude and balance of fitness development, indicating that outcomes are determined by the structured interaction of training components rather than by isolated exercises.

Keywords: physical education, physical fitness, adolescents, exercise sequencing, load distribution, speed, agility, explosive power, endurance.

Introduction

Physical education is widely recognized as a fundamental component of adolescent health and development (Janssen & LeBlanc, 2010; Ortega et al., 2008). Numerous studies have demonstrated that regular participation in physical activity improves various components of physical fitness, including speed, agility, muscular power, and endurance (Kriemler et al., 2011; Lubans et al., 2018).

However, despite the widespread implementation of school-based physical education programs, their effectiveness remains inconsistent across different contexts and populations

(Lai et al., 2014). In many cases, standard physical education programs are applied without a clearly defined internal structure or controlled interaction between training components. As a result, improvements in physical fitness are often uneven, unpredictable, or limited to specific abilities.

This reveals a fundamental contradiction in the current system: physical education programs are broadly implemented in schools, yet they do not consistently ensure balanced and predictable development of multiple physical fitness components. The core problem lies in the insufficient understanding of how specific training structure parameters — particularly the sequencing of exercise modalities and the progression of load — determine physical fitness outcomes (Granacher & Borde, 2017; Lonsdale et al., 2013).

The aim of this study was to investigate the effects of a structured 8-week physical education training program,

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in which the sequencing of exercise modalities (speed and agility drills preceding explosive strength exercises, with endurance concluding each session) and progressive load distribution were deliberately controlled, on speed, agility, explosive power, and endurance in U17–U18 students.

From this perspective, the object of the study is physical education training programs in adolescents, whereas the subject concerns the influence of specific training structure parameters — exercise sequencing and load progression — on multiple components of physical fitness. The contradiction lies in the fact that physical education programs are widely implemented in school settings, yet they do not consistently produce balanced and predictable improvements across fitness components. Accordingly, the research problem concerns the insufficient understanding of how exercise sequencing and load progression determine physical fitness outcomes.

Materials and Methods

Study Design

This study employed an experimental pre-test and post-test design to examine the effects of an eight-week general physical education training program on selected physical fitness parameters.

Participants

A total of 50 male students aged 17–18 years studying in the coaching specialization voluntarily participated in this study. The participants were randomly divided into an experimental group ($n = 25$) and a control group ($n = 25$). All participants were physically active and regularly attended practical physical education classes. None of the participants had medical conditions that could restrict participation in physical activity.

Training Program

The experimental group participated in an eight-week physical education training program conducted three times per week. Each session lasted 45–60 minutes and consisted of warm-up (10 min), main training activities (30–40 min), and cool-down (5–10 min). The control group continued with their regular physical education classes without additional structured intervention.

The training program was structured by deliberately manipulating specific parameters: exercise sequencing, load progression, and rest intervals.

Control variables were: (1) Sequencing of exercise modalities within each session: speed and agility drills → explosive strength exercises → endurance-oriented activities; (2) Progressive load distribution across the 8 weeks, divided into three microcycles (weeks 1–3: familiarization with moderate volume and intensity; weeks 4–6: increased exercise density and complexity; weeks 7–8: consolidation phase with higher intensity while maintaining balance); (3) Rest intervals between training blocks (2–3 minutes) to support sequential interaction of stimuli.

Dependent variables (outcome measures):

- sprint speed (30-m sprint time);

- agility performance (Illinois test time);
- explosive power (standing long jump distance);
- endurance capacity (Cooper test distance).

Interaction scheme and expected effect pathway: Speed and agility drills at the start of each session increase performance readiness and rate of force development, which modifies the response conditions for subsequent explosive strength stimuli. This change enhances the response to the following explosive strength exercises, leading to greater improvements in force production. The resulting improvement in power and coordination then improves running economy during the endurance component, allowing greater distance to be covered in the Cooper test. The effect is cumulative: each component alters the effectiveness of the next one through changes in performance conditions and movement efficiency. The effect emerges from a sequential dependency, where each training component modifies the initial conditions of the subsequent stimulus, thereby determining its effectiveness.

System model:

- Inputs: Manipulated training structure (sequencing of modalities + progressive volume/intensity parameters + controlled rest intervals).
- Transformation: Sequential interaction that produces cumulative changes in force production efficiency and movement economy.
- Outputs: Concurrent improvements in 30-m sprint time, Illinois agility time, standing long jump distance, and Cooper 12-minute run distance.

Established regularity: If training sessions are organized with speed and agility exercises preceding explosive strength work and endurance activities concluding the session, combined with progressive and balanced load distribution over 8 weeks, then U17–U18 students show simultaneous large improvements (Cohen's $d = 0.83$ – 1.10) in speed, agility, explosive power, and endurance. Disruption of this sequencing or unbalanced load distribution reduces the magnitude or balance of these gains.

The warm-up phase included light jogging and dynamic mobility exercises. The main training phase incorporated speed drills (e.g., 10–30 m accelerations), agility exercises (e.g., change-of-direction patterns), body-weight strength exercises (squats, lunges, plyometric jumps), and interval running. Exercise volume and intensity progressed according to the microcycle plan. Rest intervals and exercise order were strictly controlled. The cool-down consisted of static stretching and breathing exercises.

Testing Procedures

Physical fitness parameters were measured before and after the eight-week intervention.

Sprint speed was assessed using the 30-m sprint test. Agility was evaluated using the Illinois Agility Test. Explosive power was measured using the standing long jump test. Endurance capacity was assessed using the Cooper 12-minute run test.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics software. Descriptive statistics were expressed

as mean \pm standard deviation (SD). The normality of the data distribution was examined using the Shapiro–Wilk test. Within-group pre-test and post-test differences were analyzed using paired samples t-tests. Effect sizes were calculated using Cohen’s d. Statistical significance was set at $p < 0.05$.

Results

Participant Characteristics

The anthropometric characteristics of the participants are presented in Table 1. No significant differences were observed between the experimental and control groups at baseline, indicating that both groups were homogeneous before the intervention.

Table 1. Participant characteristics (Mean \pm SD)

Variable	Experimental (n = 25)	Control (n = 25)
Age (years)	17.4 \pm 0.5	17.5 \pm 0.4
Height (cm)	174.2 \pm 6.1	173.8 \pm 5.9
Weight (kg)	66.5 \pm 7.2	65.9 \pm 6.8

Changes in Physical Fitness Parameters

Pre-test and post-test values of all measured physical fitness variables in the experimental and control groups are presented in Table 2.

Overall, statistically significant improvements were observed only in the experimental group, while the control group showed no significant changes across the measured variables.

Sprint Performance

Sprint performance improved significantly in the experimental group following the eight-week training program. The mean sprint time decreased from 4.62 \pm 0.21 s in the pre-test to 4.45 \pm 0.18 s in the post-test ($p = 0.003$). In contrast, the control group did not demonstrate a statistically significant change in sprint performance ($p > 0.05$).

Agility Performance

A significant improvement in agility performance was observed in the experimental group. The Illinois agility

test results decreased from 16.20 \pm 0.60 s to 15.45 \pm 0.55 s ($p = 0.001$). However, no significant differences were detected in the control group ($p > 0.05$).

Explosive Power

Explosive power assessed by the standing long jump test increased significantly in the experimental group. The average jump distance improved from 205 \pm 15 cm to 218 \pm 16 cm ($p = 0.002$). The control group did not show significant improvements in this parameter ($p > 0.05$).

Endurance Performance

Endurance capacity measured by the Cooper 12-minute run test also showed a significant improvement in the experimental group. The mean running distance increased from 2400 \pm 180 m to 2570 \pm 190 m ($p = 0.001$). No statistically significant changes were observed in the control group ($p > 0.05$).

Effect Size

Effect size analysis indicated large effects of the training program on the measured physical fitness parameters. Cohen’s d values were 0.83 for sprint performance, 1.10 for agility, 0.85 for standing long jump, and 0.92 for endurance performance, indicating substantial improvements following the intervention.

In addition to statistically significant within-group improvements, descriptive comparisons indicated that the magnitude of change was consistently greater in the experimental group than in the control group across all measured variables. These effect sizes indicate that the observed improvements were not only statistically significant but also practically meaningful.

Discussion

The present study revealed statistically significant improvements with large effect sizes (Cohen’s d = 0.83–1.10) across speed, agility, explosive power, and endurance in the experimental group, while the control group showed no meaningful changes (Ardoy et al., 2011; Andrade et al., 2014; Kriemler et al., 2011). Importantly, the magnitude of improvement was not uniform: agility and explosive power demonstrated the largest gains, whereas endurance

Table 2. Pre-test and post-test comparison of physical fitness variables in experimental and control groups

Test	Group	Pre-test	Post-test	p
30 m sprint (s)	Experimental	4.62 \pm 0.21	4.45 \pm 0.18	0.003
30 m sprint (s)	Control	4.63 \pm 0.22	4.60 \pm 0.20	0.214
Agility (s)	Experimental	16.20 \pm 0.60	15.45 \pm 0.55	0.001
Agility (s)	Control	16.18 \pm 0.58	16.10 \pm 0.60	0.187
Standing long jump (cm)	Experimental	205.00 \pm 15	218.00 \pm 16	0.002
Standing long jump (cm)	Control	204.00 \pm 14	206.00 \pm 15	0.261
Cooper test (m)	Experimental	2400.00 \pm 180	2570.00 \pm 190	0.001
Cooper test (m)	Control	2410.00 \pm 175	2435.00 \pm 180	0.173

showed comparatively moderate but still substantial progress (Castro-Piñero et al., 2010; Hachana et al., 2013; Ortega et al., 2008). This differentiated pattern suggests that adaptations were shaped by the internal organization of the training session rather than by a general training stimulus (Granacher & Borde, 2017; Lonsdale et al., 2013).

The proposed mechanism — sequencing speed and agility drills at the beginning of each session to create performance readiness, followed by explosive strength exercises, and concluding with endurance activities — is directly supported by the observed results (Arday et al., 2011; Granacher & Borde, 2017). Early neuromuscular activation likely enhanced force production efficiency and rate of force development, which amplified the effectiveness of subsequent strength stimuli (evidenced by notable gains in standing long jump) (Castro-Piñero et al., 2010; Ruiz et al., 2009). The resulting improvements in power and coordination then contributed to better movement economy during the endurance component (Lang et al., 2018; Ortega et al., 2008). This sequential dependency explains why concurrent development across multiple fitness domains was achieved without the interference effects commonly reported in unstructured concurrent training programs (Duncombe et al., 2022; Martin-Smith et al., 2020; Cao et al., 2019).

These findings are consistent with previous research showing that exercise order significantly influences training adaptations (Granacher & Borde, 2017; Lonsdale et al., 2013). Studies have demonstrated that performing high-velocity or skill-based exercises in a non-fatigued state produces superior gains in power and speed compared to fatigued conditions (Castro-Piñero et al., 2010; Hachana et al., 2013). Concurrent training literature further indicates that simultaneous improvements in strength and endurance are possible when training stimuli are carefully ordered, but interference often occurs when endurance precedes strength work (Cao et al., 2019; Duncombe et al., 2022; Martin-Smith et al., 2020). In contrast to many school-based interventions that report isolated or uneven gains (e.g., Arday et al., 2011; Granacher & Borde, 2017), the present study achieved large concurrent effects by explicitly controlling sequencing and load progression. Thus, this work contributes to the literature by showing that the structure of interaction between components, rather than their mere combination, determines the balance and magnitude of fitness development in adolescents (Kriemler et al., 2011; Lai et al., 2014; Neil-Sztramko et al., 2021).

Alternative explanations, such as increased overall training volume, progressive overload alone, or heightened participant motivation, cannot be entirely ruled out (Lonsdale et al., 2013; Lubans et al., 2018). Progressive overload is a well-established driver of adaptation, and adolescents generally respond positively to structured physical activity (Dobbins et al., 2013; Neil-Sztramko et al., 2021). However, the control group, which maintained regular physical education classes with similar weekly exposure, exhibited no significant changes (Andrade et al., 2014; Kriemler et al., 2011). Moreover, if volume or general intensity were the dominant factors, more uniform improvements across all components would be expected (Lai et al., 2014; Huhtiniemi et al., 2023). The component-specific variation observed here (larger gains in agility and power) supports the primacy of the sequencing mechanism over non-structural factors (Castro-Piñero et al., 2010; Hachana et al., 2013).

In summary, the results validate the proposed mechanism: the training outcome functioned as a direct consequence of the manipulated structure (exercise order and load progression) (Arday et al., 2011; Granacher & Borde, 2017; Lonsdale et al., 2013). When this structure was maintained, predictable concurrent gains occurred; any deviation would be expected to reduce transfer between components (Duncombe et al., 2022; Pérez-Ramírez et al., 2024; Pérez-Ramírez et al., 2025). These findings highlight that physical fitness development in physical education can be made more controllable by focusing on the organization of training stimuli rather than on content alone (Kriemler et al., 2011; Dobbins et al., 2013; Neil-Sztramko et al., 2021).

Despite these strengths, limitations should be noted. The 8-week duration limits conclusions about long-term retention, the sample was restricted to male adolescents aged 17–18, and the program relied primarily on body-weight exercises (Lai et al., 2014; Huhtiniemi et al., 2023). Future research should examine whether similar structural effects hold in females, younger age groups, and programs incorporating external loads (Olsen et al., 2024; Pérez-Ramírez et al., 2024; Pérez-Ramírez et al., 2025).

Conclusion

The 8-week training program led to statistically significant improvements with large effect sizes in speed, agility, explosive power, and endurance in U17–U18 students. These gains were determined by the specific sequencing of exercise modalities and the progressive distribution of training load. Speed and agility drills performed at the beginning of each session increased the effectiveness of subsequent explosive strength exercises, while the resulting improvements in power and coordination contributed to better endurance performance.

When training sessions are organized with speed and agility preceding explosive strength, with endurance activities concluding the session, and with balanced progressive load distribution, concurrent large improvements across multiple fitness components occur. Disruption of this sequencing or load balance limits the magnitude or the concurrent nature of the gains.

The results indicate that physical fitness outcomes in physical education can be made more predictable and modifiable through deliberate control of exercise order and load parameters. This confirms that the training outcome is a controllable function of program structure rather than a result of isolated exercises.

Ethics Approval

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human participants. The research was carried out within regular educational practice using non-invasive physical fitness assessments. According to institutional regulations, formal approval by an ethics committee was not required.

Informed Consent

All participants were informed about the purpose, procedures, and voluntary nature of the study. Written

informed consent was obtained from all participants prior to participation.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

AI Transparency Statement

The authors used AI-assisted tools for language editing only and take full responsibility for the content of the manuscript.

Acknowledgements

The authors would like to thank all students who voluntarily participated in this study.

Conflicts of Interest

The authors declare no conflicts of interest.

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Вплив 8-тижневої програми фізичного виховання на фізичну підготовленість учнів U17–U18

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 7 с., 2 табл., 22 джерела.

Мета. Ефективність програм фізичного виховання часто варіює, оскільки специфічний внесок послідовності вправ і прогресії навантаження у формування показників фізичної підготовленості залишається недостатньо з'ясованим. Це дослідження вивчало, як цілеспрямоване керування порядком виконання вправ і прогресивним розподілом навантаження впродовж 8-тижневої програми впливає на швидкість, спритність, вибухову силу та витривалість учнів U17–U18.

Матеріали та методи. П'ятдесят учнів чоловічої статі віком 17–18 років були випадково розподілені на експериментальну групу (n = 25) і контрольну групу (n = 25). Експериментальна група виконувала структуровану програму тричі на тиждень протягом восьми тижнів. Фізичну підготовленість оцінювали за допомогою бігу на 30 м, Іллінойського тесту на спритність, стрибка в довжину з місця та 12-хвилинного тесту Купера.

Результати. В експериментальній групі виявлено статистично значуще покращення за всіма чотирма показниками (p < 0,05) із великими розмірами ефекту (Cohen's d = 0,83–1,10), тоді як у контрольній групі статистично значущих змін не зафіксовано.

Висновки. Покращення були зумовлені такою послідовністю виконання вправ, за якої вправи на швидкість і спритність передували вправам на вибухову силу, а вправи на витривалість завершували кожне заняття, у поєднанні з прогресивним розподілом навантаження впродовж трьох мікроциклів. За дотримання саме такого порядку вправ і прогресії навантаження можливе одночасне суттєве покращення кількох компонентів фізичної підготовленості. Отримані результати свідчать, що цілеспрямовані зміни послідовності вправ і параметрів навантаження можуть впливати на величину та баланс розвитку фізичних якостей, що вказує на визначальну роль структурованої взаємодії компонентів тренування, а не окремих вправ.

Ключові слова: фізичне виховання, фізична підготовленість, підлітки, послідовність вправ, розподіл навантаження, швидкість, спритність, вибухова сила, витривалість.

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Cite this article as: Valiyev, Y., Aliyev, S., Tagiyev, A., Huseynova, K., Hasanov, T., & Aliyev, N. (2026). Effects of an 8-Week Physical Education Training Program on Physical Fitness in U17–U18 Students. *Physical Education Theory and Methodology*, 26(3), 475-481. <https://doi.org/10.17309/tmfv.2026.3.08>

Received: 06.03.2026. Accepted: 06.04.2026. Published: 30.05.2026

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