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The Educational Role of Athletics in Physical Education: Effects on the Physical and Motor Development of Lower Secondary Students (Part I)

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Abstract: *This paper explores the effects of a structured athletics-based physical education program on the physical development of secondary school students. The experimental intervention was implemented throughout the 2023–2024 academic year in two urban schools and involved integrating age-appropriate running, jumping, and throwing exercises into regular physical education classes. Sixty students aged 11–12 were assigned to experimental and control groups. Statistical analysis revealed significant improvements in the experimental group compared to the control group. Key anthropometric indicators included a +1.8 cm increase in height ($t = 13.80$; $p < 0.0005$), a +1.06 kg gain in body weight ($t = 6.72$; $p < 0.0005$), and a +1.38 unit enhancement in thoracic elasticity ($t = 15.83$; $p < 0.0005$). These findings demonstrate the formative impact of athletics content on somatic growth, postural development, and respiratory function during preadolescence. The results validate the inclusion of athletics-based activities in the physical education curriculum as an effective means to support students' physical development, without emphasizing competitive performance.*

Keywords: *physical development; secondary school; physical education; athletics; anthropometry; experimental study; somatic growth.*

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Introduction

Introduction Physical education and school sports, as components of the educational system, are not ends in themselves, but are instead structured systems of activities designed to develop students' biological, psychological, and social potential. In contemporary education, physical education represents a distinct curricular area with clearly defined goals, objectives, and content. These are grounded in specific teaching methodologies and instructional strategies that ensure both the achievement of outcomes and the objective evaluation of student progress.

The objectives of school-based physical education encompass a broad spectrum: promoting and maintaining health, supporting proper and aesthetically balanced posture, improving the functional capacity of the respiratory and cardiovascular systems, contributing to harmonious physical development, and fostering personality traits such as perseverance, self-discipline, and moral integrity. Additionally, it aims to develop aesthetic awareness, rhythmic coordination, and the ability to assess performance, encouraging the formation of healthy habits through regular physical activity (Balint & Badicu, 2023; De Meester et al., 2018; De Meester, et al., 2020; Lopes et al., 2021; World Health Organization, 2024).

At the secondary school level, these objectives are operationalized through the development of general competencies in physical education (Table 1), tailored to the ontogenetic stage of learners. Designing and conducting physical education activities without considering students' anatomical and physiological characteristics can adversely affect growth and development (Balint & Badicu, 2023; De Meester et al., 2018; De Meester et al., 2020; Ministerul Educației Naționale, 2017).

Table 1. General competencies specific to physical education and sports in lower secondary education.

No.	Competency
1	Applying the beneficial effects of physical education and sports through regular physical activity aimed at optimizing health.
2	Using knowledge and skills acquired in physical education and sports to support harmonious physical development and motor ability.
3	Adopting behavior that respects specific rules during the organization, practice, or as a spectator of physical education and sports activities.

Source: Adapted from the National Curriculum for Physical Education (Ministerul Educației Naționale/ Ministry of National Education, 2017).

Recent literature emphasizes the need to tailor motor development strategies to students' age and stage of growth. Early motor experiences significantly influence long-term physical and psychological development (De Meester et al., 2020; Lopes et al., 2021; Pesce et al., 2021). Sensitive periods for developing key capacities—such as coordination, strength, and speed—should be purposefully addressed in curricular planning, especially during puberty, a dynamic and sensitive developmental stage (Khankeldiev & Sotvoldieva, 2022; Hudson, & Willoughby, 2021; Pesce et al., 2016).

Curriculum-based physical education interventions have demonstrated significant improvements in motor competence among school-aged children, including those in the preadolescent stage (Coe et al., 2024; Lorås 2020; Reis et al., 2024; Vanluyten et al., 2024). Moreover, school-based programs that integrate fundamental movement skills have shown substantial progress in motor capacity development among children in the prepubescent and preadolescent phases (Formenti et al., 2020; Yu et al., 2018).

Participation in physical education and sports is positively associated with personality traits such as extraversion, conscientiousness, and openness to experience, which in turn support self-regulation, motivation, and academic success. Physical activity fosters a sense of responsibility, perseverance, and emotional control, all of which contribute to improved behavior and social integration in school (Biino et al., 2023; Formenti et al., 2020; Pesce et al., 2021; Stănescu et al., 2020; Willoughby & Hudson, 2023).

Engagement in physical activity also satisfies basic psychological needs—autonomy, competence, and relatedness—as conceptualized in Self-Determination Theory. This theoretical framework is widely applied in school-based physical education to promote intrinsic motivation and active participation (De Meester et al., 2018; Moradi et al., 2020; Ryan & Deci, 2020; St. Laurent et al., 2021).

Physical education contributes to the development of both interpersonal (e.g., cooperation, empathy) and intrapersonal (e.g., self-control, goal setting) skills, fostering a positive school climate and enhancing students' adaptive capacities. The transferability of these skills to other domains, including academic performance and everyday life, reinforces the formative role of physical education (Bean et al., 2016; Brown et al., 2017; Hil et al., 2024; Owen et al., 2022; Khan et al., 2021; Wollesen et al., 2022).

Athletics, as a fundamental discipline within the physical education curriculum, supports the acquisition of essential motor skills and contributes significantly to postural correction, respiratory function, coordination, and muscular development. Due to its accessible and natural character, athletics is particularly suitable for school settings across all age levels (Barenie et al., 2025; Costa et al., 2021).

Athletic exercises emphasize both correct execution and the development of physical capacities necessary for movement efficiency. In the long term, these benefits support increased resilience to physical and mental effort and foster autonomy in maintaining an active lifestyle (Chaput et al., 2020; Jones et al., 2020). Recent research by Enoiu et al. (2025) highlights the impact of targeted motor and coordinative skills training on vaulting performance in junior gymnasts, reinforcing the value of structured athletic content in physical education. Moreover, athletic motor skill competencies are associated with maturation, motivation, and health indicators during adolescence (Koolwijk et al., 2024; Pullen et al., 2022).

In this context, the role of physical education and athletics in secondary education is vital to the harmonious physical and motor development of students during the critical pubertal stage. While the literature provides extensive insights into general motor development, the specific impact of athletics-based physical education on motor capacity during preadolescence remains underexplored. This gap calls for empirical research to assess the effectiveness of structured athletics programs in supporting both physical development and the broader educational mission of physical education.

Problem Statement

Athletics in School Physical Education

Based on the experience accumulated over time as a coach and secondary school physical education teacher, we consider that the main arguments supporting the inclusion of athletics as a core discipline within the National Curriculum for physical education, at all levels of education, are as follows:

- Athletic exercises can be scheduled throughout the entire school year without requiring special material conditions or complex infrastructure;
- They consist of natural, instinctive movements that are accessible to children of all ages, with a low level of complexity but high utility value in the development of basic motor skills;
- Athletic activities allow for the objectification of physical effort through precise quantification and measurement (expressed in centimeters, meters, seconds, minutes, etc.), which facilitates clear evaluation of progress;
- Their positive influence on harmonious physical development is significant, targeting both the locomotor system and major

physiological functions, particularly during growth phases such as puberty (ages 10–14);

- Events such as running, jumping, and throwing are among the most effective and accessible means used in physical education lessons to achieve curricular objectives, especially the development of essential motor abilities;
- Athletics is typically practiced outdoors, which supports the hardening of the body, strengthens the organism, and increases general endurance and physical work capacity;
- Due to the individual nature of athletic events, they contribute to the development of volitional traits such as perseverance, tolerance to effort, self-discipline, and the capacity for autonomous performance.

To operationalize the educational objectives defined in the curriculum, athletics is structured into three major instructional modules - *School of Running*, *School of Jumping*, and *School of Throwing*. These modules support the development of targeted motor abilities through age-appropriate learning progressions. Within school physical education, particularly at the lower secondary level, structured activities focus on technical initiation, control of movement execution, and the consolidation of motor skills through progressive and adaptable methods.

Each instructional module emphasizes different motor and coordinative demands: running exercises promote dynamic control and movement efficiency; jumping develops explosive strength and spatial-temporal orientation; throwing focuses on functional strength and gesture precision. These components are approached not only physically but also conceptually, incorporating knowledge about technique, rules, safety, and responsibility.

Through systematic practice and variation (see Tables 2–4), students are exposed to a broad spectrum of physical stimuli, contributing to the refinement of posture, balance, coordination, and effort capacity. This modular approach bridges theoretical principles with pedagogical application and supports both performance improvement and the internalization of positive behaviors in physical education.

Within the thematic lessons dedicated to speed running, students practice the acceleration stride, the launched sprinting step, and the crouch start, with emphasis on applying these techniques in competitive contexts over short distances ranging from 10 to 60 meters, including sprint finishing techniques. Instruction also includes essential knowledge related to false starts, lane discipline, and the specific regulations governing sprint events in official competitions.

The endurance running component focuses on covering distances between 400 and 1000 meters under conditions simulating real race scenarios. The instructional activities target the learning of the standing start, coordination of breathing with stride rhythm, and adaptation to varied terrain. Students also receive theoretical input on false starts, overtaking techniques, the biomechanics of foot-ground contact based on surface type, and the rules associated with middle- and long-distance running events in competitive settings.

An additional module targets hurdle running, emphasizing the technical aspects of hurdle attack and the step rhythm between obstacles. Alongside physical training, students develop theoretical competencies related to refereeing, event organization, and the management of running competitions, in alignment with educational objectives that integrate both the practical and cognitive dimensions of athletic performance.

Table 2. Key instructional elements in school-based athletic running education

Category	Instructional Content
Elements from the *School of Running*	Ankle-mobility running (*alergare cu joc de gleznă*); high-knee running (*alergare cu genunchii sus*); leg pendulum running, forward and backward (*alergare cu pendulareagambelor*); variations of specific drills.
Speed Running	Acceleration stride (*pasul alergător de accelerare*); launched sprint stride (*pasul alergător lansat de viteză*); crouch start (*start de jos*); launch from the start (*lansarea de la start*); sprint finish (*finișul*); competitive format over 10–60 m.
Endurance Running	Launched middle-distance stride (*pasul alergător lansat de semifond*); standing start (*startul de sus*); breathing coordination with stride rhythm; varied-terrain running; competitive format over 400–1000 m.
Hurdle Running	Obstacle attack (*atacul obstacolului*); stride rhythm between hurdles (*ritmul pașilor între obstacole*).
Conceptual Knowledge	False starts (*startul greșit*); lane discipline (*respectarea culoarului de alergare*); overtaking (*depășirea adversarului*); foot-ground contact depending on surface; sprint and middle-/long-distance event structure in official competitions.
Organizational Aspects	Refereeing; organization and management of running events (*arbitraj, organizare și conducere*).
Supplementary Content	Sports-related informational content.

Source: Adapted from the National Curriculum for Physical Education, Grades 5–8 (Ministerul Educației Naționale/Ministry of National Education, 2017).

Note: The terminology in the table follows the original Romanian phrasing from the National Curriculum for Physical Education (MEN, 2017), in order to preserve terminological consistency and respect the educational framework.

Jumping exercises within the school athletics curriculum (see Table 3) play a key role in developing explosive strength, coordination, and spatial-temporal awareness. Lower secondary school students are introduced to the fundamental techniques of long jump and high jump through both general and specific preparatory exercises. In long jump training, the focus is placed on the technical phases—approach run, take-off, flight, and landing—which are addressed through age-appropriate instructional methods. The learning of high jump follows a progressive structure, utilizing accessible techniques such as the scissor style and the stride technique, with emphasis on safety and technical efficiency. The theoretical component includes rules, take-off zones, bars, and landing surfaces, contributing to students' understanding and sense of responsibility in the organization of events.

These exercises are also effective in correcting postural imbalances and improving dynamic balance during movement tasks. Moreover, they foster body awareness and promote autonomy in executing technically correct actions within a regulated framework. Through repeated practice and feedback-based correction, students gradually internalize biomechanically efficient movement patterns, which can be transferred to other motor contexts. In addition, jumping exercises encourage initiative, persistence, and the ability to self-regulate performance under conditions of physical and mental challenge—skills that are essential to both athletic development and broader educational outcomes.

Table 3. Key instructional elements in school-based athletic jumping education

Category	Instructional Content
Elements from the *School of Jumping*	Pasul săltat *(skipping step);* pasul sărit *(jumping step); low obstacle jumps (*sărituripesteobstacolejoase*); plurisalt drills (*plurisalturi*); variations of specific jumping drills.*
Long Jump	Long jump with 1½ steps in the air; approach run of 3–9 steps; free take-off (*bătaie liberă*) or from a designated zone (*bătaie în zonă precizată*); flight (desprindere) and landing.
High Jump	High jump with stepping technique (*săritura în înălțime cu pășire*): approach run calibration (*etalonarea elanului*), take-off (*bătaia*), lift-off (*desprinderea*), flight, and landing; high jump using alternative techniques.
Conceptual Knowledge	Exceeding the take-off board (*depășirea pragului / zonei de bătaie*); measuring jump distance; understanding technical phases; biomechanics of jumping and landing.
Organizational Aspects	Refereeing; organization and management of jumping events (*arbitraj, organizare și conducere în desfășurarea probelor*).
Supplementary Content	Sports-related informational content.

Source: Adapted from the National Curriculum for Physical Education, Grades 5–8 (Ministerul Educației Naționale/Ministry of National Education, 2017).

Note: The terminology in the table follows the original Romanian phrasing from the National Curriculum for Physical Education (MEN, 2017), in order to preserve terminological consistency and respect the educational framework.

Throwing events (see Table 4) aim to develop functional strength, general coordination, and gesture control. In lower secondary education, the focus is placed on acquiring fundamental motor skills through specific disciplines such as the oină ball throw, shot put, and introductory training in javelin throw. Instructional activities emphasize correct body positioning, the trajectory of the release, and optimal timing of object release.

To facilitate learning, adapted equipment and simplified tools are used, tailored to students' developmental level. In parallel, strong emphasis is placed on safety in execution and the development of ethical behavior during sports activities. Students also acquire knowledge of the official rules governing throwing events, including the delimitation of the throwing area, proper body posture, and the role of the referee in validating performance.

Beyond physical execution, throwing tasks require anticipatory control, coordination of complex segmental movements, and precise modulation of force. Through structured practice, students develop a better understanding of how leverage, body alignment, and kinetic chain involvement influence throwing efficiency. These activities also support the refinement of fine motor control, proprioceptive accuracy, and the ability to adapt movements based on spatial and situational demands, all of which are transferable to other physical and academic domains.

Table 4. Key instructional elements in school-based athletic throwing education

Category	Instructional Content
Elements from the *School of Throwing*	Overarm throws (*aruncări tip azvârlire*), pushing, and launching techniques performed with one or both hands; throwing the oină ball (*mingea de oină*) from a stationary position and with approach run (*cu elan*); throwing with added or crossed step (*cu pas adăugat / încrucişat*); phases include approach run (*elanul*) and blocking (*blocarea*).
Throwing Techniques	Throwing for distance; using medium approach runs (*elan mediu*); proper execution of throw (*aruncarea reuşită*); types of release techniques; distinction between pushing and launching motions.
Conceptual Knowledge	Characteristics of the oină ball; crossing the throwing line (*depăşirea liniei de aruncare*); observing the throwing sector (*respectarea sectorului de aruncare*); number of attempts in competition; measurement of throw distance.
Organizational Aspects	Refereeing; organization and management of the throwing event (*arbitraj, organizare şi conducere în desfăşurarea probei*).
Supplementary Content	Sports-related informational content.

Source: Adapted from the National Curriculum for Physical Education, Grades 5–8(Ministerul Educaţiei Naţionale/Ministry of National Education, 2017).

Note: The terminology in the table follows the original Romanian phrasing from the National Curriculum for Physical Education (MEN, 2017), in order to preserve terminological consistency and respect the educational framework.

These activities also support the refinement of fine motor control, proprioceptive accuracy, and the ability to adapt movements based on spatial and situational demands, all of which are transferable to other physical and academic domains.

The implementation of these structured athletic modules ensures coherence between curricular objectives and practical instruction. Through clear progression, task variability, and the integration of evaluation components, the athletics program conducted during physical education lessons provides a measurable, inclusive, and developmentally appropriate framework for motor education.

Physical development and education: an interdependent educational perspective

Preadolescence, typically ranging from ages 10/11 to 14/15, marks a pivotal period in a child's physical, emotional, and cognitive growth. This developmental stage is characterized by significant increases in height and body mass, hormonal changes associated with puberty, and the accelerated maturation of vital physiological systems. During this time, the body demonstrates enhanced adaptability to physical stimuli, and the responsiveness to movement-based challenges reaches a high point. These conditions create a fertile ground for structured physical education to actively contribute to the student's overall development (Albaladejo-Saura et al., 2021; Bao et al., 2024; Marsigliante et al., 2023; Ley 2020; O'Brien et al., 2023).

Physical development encompasses the continuous and dynamic process of biological growth and structural-functional maturation of the human body (Albaladejo-Saura et al., 2021; O'Brien et al., 2023; Salami et al., 2024). It involves both measurable physical changes—such as increases in height, weight, or muscle mass—and qualitative transformations, including body symmetry, coordination, and functional efficiency. These processes are profoundly influenced by hereditary, endocrine, environmental, and behavioral factors (Khodaverdi et al., 2022; Till et al., 2022). Importantly, physical development does not occur in isolation; it is shaped significantly by lifestyle choices and the quality of physical education (Chaput et al., 2020; Jones et al., 2020).

In this context, school-based physical education plays a vital dual role: as a mirror of the student's biological maturation and as a platform for delivering formative, health-promoting interventions. Structured physical education programs serve not only to facilitate optimal body shaping, postural alignment, and physiological regulation, but also to prevent sedentary tendencies and correct developmental imbalances. Especially during puberty-a time of abrupt and sometimes asymmetrical growth-physical activity can function as a stabilizing factor, contributing to both the physical equilibrium and emotional well-being of students (Albaladejo-Saura et al., 2021; Bolger et al., 2020; Di Maglie et al., 2022; Malina et al., 2015; Salami et al., 2024).

Athletics-based content such as running, jumping, and throwing provides an excellent pedagogical vehicle for achieving these objectives. These exercises develop not only muscular strength and joint mobility but also spatial orientation, balance, rhythm, and body control-competencies essential not just in sports, but in daily functional movements. Moreover, the cyclical and measurable nature of athletic tasks allows students to experience goal setting, progress monitoring, and personal achievement, which in turn reinforces motivation and self-discipline.

Thus, physical development should not be viewed merely as a biological given but as a multidimensionally supported process, enhanced by regular physical activity, lifestyle awareness, and educational interventions. Within this framework, physical education emerges as a formative discipline, capable of shaping not only the student's physical health but also their social behavior, personal responsibility, and emotional resilience (Da Costa et al., 2019; Marsigliante et al., 2023; Hudson & Willoughby, 2021; Willoughby & Hudson, 2023; Wan et al., 2021).

An integrated pedagogical approach, rooted in scientific understanding and responsive to the specific needs of preadolescents, is essential for ensuring that physical education contributes meaningfully to long-term health and personal development. When aligned with athletic content and grounded in developmental appropriateness, instruction becomes a powerful tool in promoting healthy habits, strengthening psychosocial skills, and fostering students' autonomy and self-worth.

From this multidimensional perspective, physical education transcends its traditional role, becoming an educational domain that supports biological growth, instills ethical values such as perseverance and fair play, and encourages a proactive attitude toward one's well-being. It is this holistic contribution that positions physical education as a core component of contemporary educational paradigms focused on lifelong learning, equity, and personal empowerment.

Methodology

Aim and Hypotheses of the Research

Considering preadolescence as a critical stage for shaping both physical development and active lifestyle habits, this study aims to design and implement an effective pedagogical strategy within physical education lessons at the secondary school level. The intervention focuses on the educational use of athletics-inspired exercises-particularly running, jumping, and throwing-as formative tools that can support students' harmonious and integrated physical development.

This approach is grounded in the view of physical education as a multidimensional discipline, one that contributes simultaneously to biological maturation, emotional balance, and the adoption of healthy behaviors. The pedagogical strategy proposed in this research seeks to enhance the role of physical education not merely as motor practice, but as a complex educational process aligned with the developmental needs and age-specific characteristics of middle school students.

Based on this framework, the following hypothesis was formulated:

- **H1:** The integration of athletics-based exercises into physical education lessons significantly contributes to the harmonious physical development of lower secondary school students.

Participants, location, duration, and research stages

The experimental study involved a total sample of 60 schoolchildren, aged 11–12, both boys and girls, enrolled in two urban schools. Participants were divided into two equal groups: an experimental group (n = 30) and a control group (n = 30).

The research was conducted over the 2023–2024 academic year, unfolding in several well-defined stages:

- Stage I (September 2023): Allocation of participants to experimental and control groups; review of relevant literature; design of athletics-based intervention strategies tailored to the age group.
- Stage II (October 2023): Administration of initial assessments; elaboration of structured athletics-based exercise sequences; planning of a semester-long curricular intervention, including teaching methodology and operational strategies.
- Stage III (June 2024): Final assessments; statistical analysis and interpretation of the collected data; formulation of research conclusions.

The effective intervention period spanned from October 2023 to June 2024, totaling approximately 26 weeks of activity, after subtracting the estimated 4 weeks of school holidays (winter break, spring break, and national holidays). Thus, the structured physical education program based on athletics was applied over approximately 22 weeks of instructional activity.

Inclusion criteria

- Students aged 11–12 enrolled in general physical education classes;
- Written informed consent obtained from parents or legal guardians;
- Regular school attendance during the 2023–2024 academic year;
- Medical clearance for participation in physical activity;
- No prior involvement in structured athletic training programs.

Exclusion criteria

- Students with medical contraindications for physical effort;
- Irregular school attendance or prolonged absences during the research period;
- Refusal of parental/legal consent to participate;
- Enrollment in sports clubs involving intensive athletic training (to avoid overlap with the experimental program);
- Incomplete participation in either the initial or final testing sessions.

Research methods

This research was based on an applied experimental design aimed at assessing the impact of athletics-inspired exercises on the physical development of lower secondary school students, within the framework of physical education classes. In order to validate the working hypothesis, the following scientific methods were employed:

- Literature Review and Document Analysis: To provide the theoretical foundation of the study and ensure alignment with national educational objectives, relevant curriculum documents, educational policy frameworks, and scholarly literature on physical development during puberty were analyzed.
- Pedagogical Experimental Method: A structured pedagogical experiment was conducted in two main phases:
  - ✓ The initial assessment phase, which focused on evaluating the physical status of students in both the experimental and control groups;
  - ✓ The formative phase, implemented over several weeks, during which the experimental group participated in physical education lessons incorporating athletics-based exercises such as running, jumping, and throwing.
- Physical Testing Method: Students' physical development was monitored through a set of standardized physical tests adapted to their age and the school environment. These tests targeted general

indicators of body development and were conducted using accessible tools and conditions specific to regular physical education classes.

- Statistical Method: The collected data were processed and interpreted using relevant statistical indicators, including arithmetic mean, standard deviation, standard error, coefficient of variation, independent samples t-test, and Spearman's correlation coefficient. Statistical analysis was performed using the KyPlot software to ensure accuracy and clarity in the comparison between the two groups.

Data collection procedures

Data collection took place in the gymnasiums and on the outdoor sports fields of the two participating schools, under standardized conditions. To assess general physical development and respiratory flexibility, the following anthropometric parameters were measured: body height, body weight, and thoracic circumference (recorded during both inspiration and expiration).

The basic instruments used included:

- a stadiometer for measuring body height,
- a medical scale for determining body weight,
- and a flexible measuring tape for assessing thoracic circumference.

The study was approved by the participating schools' administration and teaching staff, in accordance with national educational research protocols.

Instructional design and athletics-based content

The experimental program designed for the intervention group was developed in accordance with the athletics content outlined in the national lower secondary school curriculum, focusing on sprinting, acceleration, starting technique, long jump, and oina ball throwing. The instructional activities were tailored to the students' age-related characteristics and their stage of physical development, without aiming for athletic performance. Instead, the program prioritized individual physical progress, emphasizing the harmonious evolution of somatic growth and the strengthening of physiological functions. The main objective of the intervention was to stimulate general physical development within a structured educational framework, aligned with the pedagogical principles of school-based physical education.

Ethical considerations

All research procedures were conducted in strict adherence to ethical standards governing studies involving minors and were applied across both participating schools.

- Prior to participation, informed consent was obtained from all students' parents or legal guardians.
- Confidentiality and anonymity were ensured throughout, with no individual data disclosed at any stage.
- All assessments were non-invasive, minimizing any potential physical or emotional discomfort for the students.
- The experimental activities were integrated into regular physical education classes during school hours, without interfering with the official curriculum, and were supervised by certified physical education teachers from both institutions.

The study complied with national educational research guidelines and received formal approval from the administrations and teaching staff of the two schools involved.

Results and interpretation regarding somatic development

Interpretation of the results regarding the "height (cm)" parameter

The comparative analysis of the values recorded for the "Height (cm)" parameter reveals a general increase in both study groups, with significant differences between the experimental and control groups.

In terms of the arithmetic mean, the experimental group recorded an increase from 147.63 cm in the initial test (T.I.) to 149.43 cm in the final test (T.F.), resulting in a difference of 1.80 cm. Meanwhile, the control group increased from 148.13 cm to 149.56 cm, with a difference of 1.43 cm. Although the control group initially had slightly higher values, the progress was more pronounced in the experimental group, suggesting a greater effectiveness of the applied intervention (Table 5).

Regarding the standard error of the mean (EM), the values were similar across both groups, with only minor variations: 1.21 (T.I.) and 1.16 (T.F.) in the experimental group, compared to 1.20 and 1.19 in the control group. These results indicate good consistency in measurements and comparable precision between the two samples.

The standard deviation (±S), reflecting individual variability in relation to the mean, was slightly higher in the initial testing phase for both groups (±6.63 in the experimental group and ±6.59 in the control), and decreased at the final testing stage (±6.38 and ±6.52, respectively). The standard deviation differences (0.25 in the experimental group vs. 0.07 in the control) suggest a slight reduction in data dispersion in the experimental group, possibly indicating that the intervention contributed to more homogeneous height development.

With regard to the coefficient of variation (CV%), it decreased from 4.49% to 4.27% in the experimental group, and from 4.45% to 4.36% in the control group. Although the declines are small, they confirm a slight improvement in value uniformity, especially within the experimental group, supporting the notion of a well-calibrated intervention tailored to the participants' needs

Anthropometric parameters - including height, weight, and thoracic perimeter (measured both in inspiration and expiration) - were recorded using appropriate, calibrated instruments. The set of indicators was used to evaluate general physical development and respiratory elasticity. Timing for motor tests was performed using a stopwatch, and all measurements were recorded in metric units or time values, as appropriate.

In percentage terms, the proportion of students above the group mean remained high in the experimental group (70% at T.I. and 66.66% at T.F.), while in the control group, these values were lower (50% and 53.33%, respectively). Correspondingly, the percentages below the mean were significantly lower in the experimental group (30% and 33.33%) compared to the control group (50% and 46.66%). This reflects a favorable distribution of results in the experimental group, with more participants exceeding the group average.

In terms of the “t” test, statistically significant differences were observed in both groups. The experimental group recorded $t = 13.80$, $p < 0.0005$, indicating an extremely significant difference between the initial and final tests, attributable to the implemented intervention. The control group also recorded a significant difference ($t = 4.56$; $p < 0.0005$), although the smaller value confirms the superior impact of the program applied to the experimental group.

Table 5. Statistical results for initial and final measurements – Height (cm)

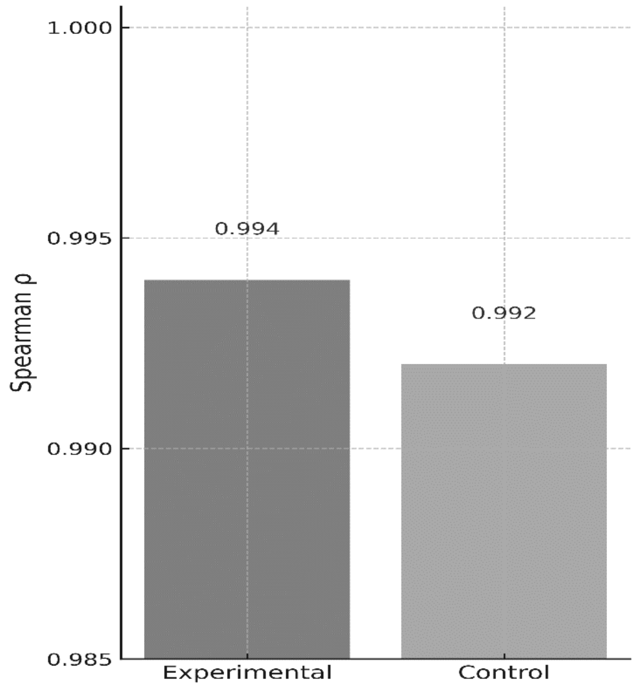
Statistical Parameter	Group	n	Initial Test (T.I.)	Final Test (T.F.)	Δ (T.F. – T.I.)
Arithmetic Mean (X̄)	Experimental	30	147.63	149.43	1.80
	Control	30	148.13	149.56	1.43
Standard Error (EM)	Experimental	30	1.21	1.16	–
	Control	30	1.20	1.19	–
Standard Deviation (±S)	Experimental	30	±6.63	±6.38	0.25
	Control	30	±6.59	±6.52	0.07
Coefficient of Variation (CV%)	Experimental	30	4.49%	4.27%	0.22
	Control	30	4.45%	4.36%	0.09
Above Average (%)	Experimental	30	70.00	66.66	–
	Control	30	50.00	53.33	–
Below Average (%)	Experimental	30	30.00	33.33	–
	Control	30	50.00	46.66	–
Student's t-test	Experimental	30	t = 13.80; p < 0.0005		–
	Control	30	t = 4.56; p < 0.0005		–

Source: author's own conception

To further examine the internal consistency of height development among students in both groups, the Spearman rank correlation coefficient (ϱ) was employed to evaluate the relationship between initial and final measurements. In the experimental group, the coefficient reached a value of $\varrho = 0.994$ ($p < 0.0001$), indicating an exceptionally strong positive correlation. This result confirms that students maintained their relative height positions throughout the intervention, suggesting uniform and harmonious somatic development. The consistency of rankings reinforces the idea that the applied physical education program was not only safe but also respectful of individual ontogenetic trajectories.

Similarly, the control group displayed a very high correlation coefficient ($\varrho = 0.992$, $p < 0.0001$), reflecting natural physiological growth in the absence of an intervention. The marginal difference in favor of the experimental group suggests that the structured program may have contributed to slightly more regulated growth dynamics. These findings support the notion that a well-calibrated physical education program, aligned with anatomical and developmental characteristics, can enhance the quality and uniformity of somatic growth without altering its natural rhythm.

Figure 1. Spearman rank correlation coefficients (ϱ) for height measurements in the experimental and control groups



Source: author's own conception

The figure 1 illustrates the strength of association between initial and final height rankings, revealing a slightly stronger correlation in the experimental group ($\varrho = 0.994$, $p < 0.0001$) than in the control group ($\varrho = 0.992$, $p < 0.0001$). This suggests greater consistency in somatic development among students exposed to the structured physical education program.

All analyzed parameters converge toward the conclusion that the program applied to the experimental group-specifically, participation in a structured athletics-based program implemented within physical education classes-had more pronounced positive effects on height development compared to the control group. The greater average gains, reduced variability, higher proportion of students above the mean, and statistically significant differences support the effectiveness and validity of the implemented intervention.

Interpretation of the results regarding the "weight (kg)" parameter

The comparative analysis of the results for the "Weight (kg)" parameter shows progress in both the experimental and control groups, although with distinct trends in variability and distribution.

The arithmetic mean for the experimental group increased from 37.90 kg (T.I.) to 38.96 kg (T.F.), with a difference of 1.06 kg. In the control group, weight increased from 36.86 kg to 38.00 kg, yielding a slightly higher difference of 1.14 kg. Despite the slightly larger gain in the control group, further analysis reveals differences in consistency and dispersion (Table 6).

The standard error of the mean (EM) decreased in both groups—0.97 to 0.88 in the experimental group and 0.86 to 0.81 in the control group—indicating improved measurement precision over time.

In terms of standard deviation (±S), both groups showed a reduction, which suggests lower variability in the final test: a decrease of 0.49 in the experimental group and 0.27 in the control group. This indicates a more homogeneous distribution of results, particularly in the experimental group.

Table 6. Statistical results for initial and final measurements – Weight (kg)

Statistical Parameter	Group	n	Initial Test (T.I.)	Final Test (T.F.)	Δ (T.F. – T.I.)
Arithmetic Mean (X̄)	Experimental	30	37.90	38.96	1.06
	Control	30	36.86	38.00	1.14
Standard Error (EM)	Experimental	30	0.97	0.88	–
	Control	30	0.86	0.81	–
Standard Deviation (±S)	Experimental	30	±5.35	±4.86	0.49
	Control	30	±4.74	±4.47	0.27
Coefficient of Variation (CV%)	Experimental	30	14.12%	12.49%	1.63
	Control	30	12.87%	11.76%	1.11
Above Average (%)	Experimental	30	63.33	73.33	–
	Control	30	70.00	66.66	–
Below Average (%)	Experimental	30	36.66	26.66	–
	Control	30	30.00	33.33	–
Student's t-test	Experimental	30	t = 6.72; p < 0.0005		–
	Control	30	t = 9.10; p < 0.0005		–

Source: author's own conception

The coefficient of variation (CV%) dropped more substantially in the experimental group (14.12% to 12.49%; Δ = 1.63%) compared to the control (12.87% to 11.76%; Δ = 1.11%), confirming improved uniformity in body weight following the intervention.

Regarding distribution, above-average performances increased in the experimental group from 63.33% to 73.33%, while they decreased slightly in the control group from 70.00% to 66.66%. Conversely, the percentage of below-average results decreased in the experimental group (from 36.66% to 26.66%), indicating a shift toward improved group cohesion and progress. In contrast, the control group showed a small increase in sub-average values.

Statistical validation via the t-test confirmed that the observed changes were highly significant in both groups: $t = 6.72$ ($p < 0.0005$) for the experimental group and $t = 9.10$ ($p < 0.0005$) for the control. However, despite the higher t value in the control group, the greater reduction in variability and improved performance distribution in the experimental group highlight the qualitative impact of the intervention—namely, the structured athletics-based program implemented within physical education classes.

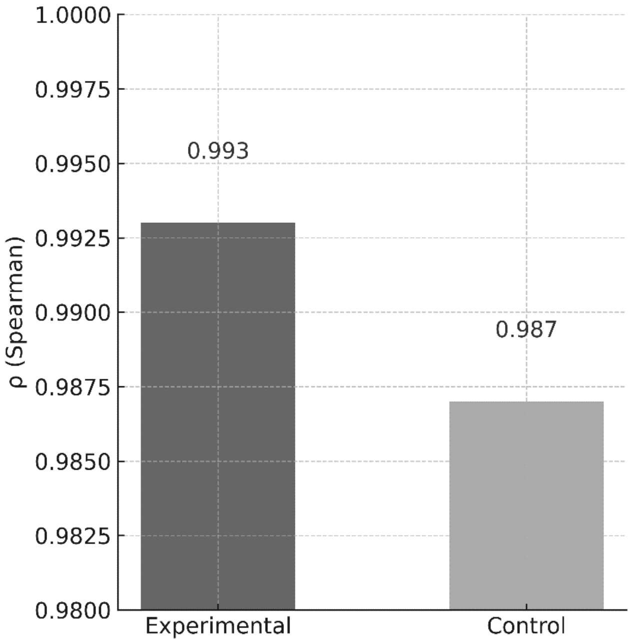
To further investigate the consistency of weight progression among participants, the Spearman rank correlation coefficient (ϱ) was employed to assess the strength of association between the initial and final rankings within each group.

In the experimental group, the analysis yielded a very strong positive correlation ($\varrho = 0.993$, $p < 0.0001$), confirming that students maintained their relative positions in terms of weight throughout the intervention. This high degree of rank-order stability suggests that the structured physical education program fostered a coherent and balanced somatic evolution. The minimal positional shifts imply that the intervention was neither disruptive to normal growth nor did it produce uneven effects among participants. Rather, it aligned with the ontogenetic rhythms of development, contributing to a steady and predictable increase in body mass.

Similarly, the control group exhibited a strong positive correlation ($\varrho = 0.987$, $p < 0.0001$) between the initial and final weight rankings. This result reflects the expected physiological growth patterns in the absence of a targeted intervention. Students with higher weight at baseline generally remained heavier at the end of the study period, indicating a natural and undisturbed developmental trajectory.

Although both coefficients are close to 1, the slightly higher correlation in the experimental group may reflect the beneficial effect of the athletics-based physical education program in promoting a more regulated and harmonious weight development process. The internal consistency of the rankings, combined with a reduction in variability and a more favorable distribution of results, supports the conclusion that the intervention contributed to improved somatic balance without altering the natural pace of growth.

Figure 2. Spearman rank correlation between initial and final weight (kg) values in the experimental and control groups.



Source: author's own conception

Figure 2 illustrates the strength of association between initial and final weight rankings, revealing a slightly stronger correlation in the experimental group (ϱ = 0.993, $p < 0.0001$) than in the control group (ϱ = 0.987, $p < 0.0001$). This suggests greater consistency in somatic development among students exposed to the structured physical education program.

Interpretation of the thoracic elasticity parameter

The analysis of the statistical parameters presented in Table 7 reveals a significant improvement in thoracic elasticity in both groups, with a more pronounced evolution observed in the experimental group, as a result of participation in a structured athletics-based program implemented within physical education classes.

The arithmetic mean of thoracic elasticity in the experimental group increased from 3.13 at the initial evaluation (T.I.) to 4.60 at the final evaluation (T.F.), indicating a difference of 1.38 units. Similarly, the control group recorded an increase from 3.30 to 4.30, with a difference of 1.00 units, reflecting progress, though to a lesser extent than in the experimental group.

The standard error of the mean (SE) remained low in both groups, ranging between 0.06 and 0.09, suggesting a high degree of precision in the mean values. Regarding the standard deviation (±SD), a slight increase was noted in the final evaluation within the experimental group (±0.49 compared to ±0.43 at T.I.), which may indicate a greater variability in individual response to the kinetic program. In the control group, the standard deviation decreased slightly from ±0.46 to ±0.43, with minimal differences between the evaluations (0.03 in the control and 0.06 in the experimental group).

Table 7. Statistical Comparison of Initial and Final Results – Thoracic Elasticity

Parameters	Group	T.I.	T.F.	Δ (T.F. – T.I.)
Arithmetic Mean (X̄)	Experimental	3.13	4.60	1.38
	Control	3.30	4.30	1.00
Standard Error (EM)	Experimental	0.07	0.09	-
	Control	0.06	0.07	-
Standard Deviation (±S)	Experimental	±0.43	±0.49	0.06
	Control	±0.46	±0.43	0.03
Coefficient of Variation (%)	Experimental	13.85%	10.83%	3.02
	Control	11.14%	11.22%	2.90
Above Average (%)	Experimental	16.66	60.00	-
	Control	30.00	80.00	-
Below Average (%)	Experimental	83.33	40.00	-
	Control	70.00	20.00	-
Student's t-test	Experimental	t = 15.83; p < 0.0005		-
	Control	t = 5.46; p < 0.0005		-

Source: author's own conception

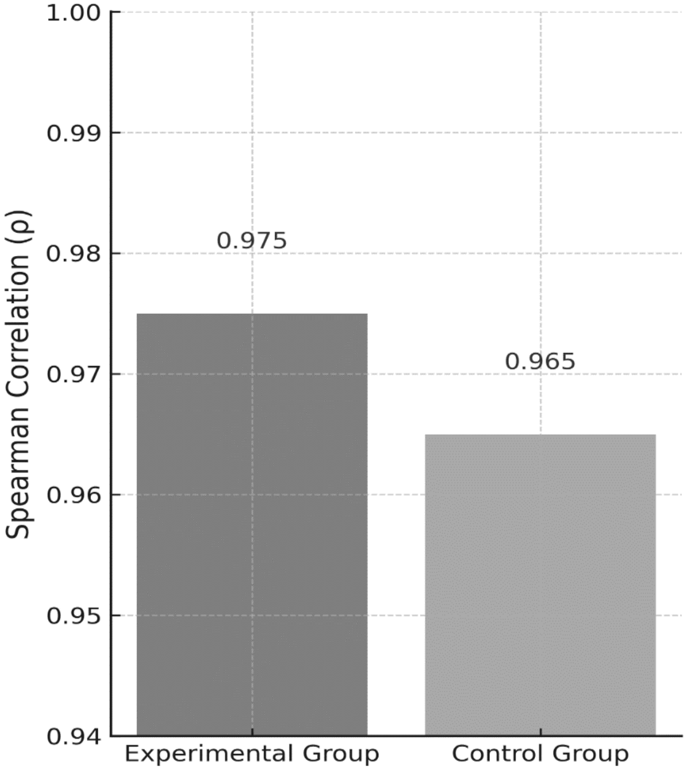
The coefficient of variation (CV%), an indicator of group homogeneity, decreased in the experimental group from 13.85% to 10.83%, suggesting an improved consistency in participant responses due to the intervention. In contrast, the control group maintained a relatively constant variability, with values of 11.14% at T.I. and 11.22% at T.F., indicating the absence of a significant homogenizing effect.

The percentage distribution of participants above and below the group mean showed a notable shift in the experimental group. The proportion of participants above the mean increased from 16.66% to 60%, while those below the mean decreased from 83.33% to 40%, highlighting a positive shift of the entire distribution toward higher performance. In the control group, an increase was also recorded in the percentage of those above the mean (from 30% to 80%), although this was not accompanied by a substantial reduction in variability, possibly reflecting a natural learning effect or non-specific influences.

Direct measurements of chest circumference during inspiration and expiration indicate a mean increase of +0.60 cm in inspiration and a decrease of -0.86 cm in expiration for the experimental group, signaling a clear improvement in thoracic mobility. In contrast, the control group registered a decrease of -3.17 cm in inspiration and a modest increase of +0.16 cm in expiration. These raw data support the statistical progress shown in Table 7, particularly in terms of arithmetic mean, coefficient of variation, and the t-test results, which confirm a highly significant effect ($p< 0.0005$) in the experimental group.

The application of the Student's *t*-test revealed statistically significant differences between the initial and final evaluations in both groups. In the experimental group, the result ($t = 15.83$; $p< 0.0005$) confirms a marked improvement in thoracic elasticity attributable to the implemented exercise program. In the control group, the value of $t = 5.46$, also with $p< 0.0005$, indicates a statistically significant change, though with a smaller effect size, supporting the conclusion that the specific intervention applied to the experimental group had a superior impact.

Figure 3. Spearman rank correlation between initial and final thoracic elasticity (cm) values in the experimental and control groups.



Source: author's own conception

To evaluate individual progress in thoracic elasticity within the experimental group, the Spearman rank correlation coefficient was calculated between the initial and final measurements. The result revealed a very strong positive correlation ($\varrho = 0.975$, $p < 0.0001$), indicating that students with higher elasticity values at the beginning remained among the top performers at the end. This suggests that the physical intervention applied was effective and contributed to a consistent, balanced improvement in thoracic mobility. Additionally, the percentage of students above the group average increased significantly—from 16.66% to 60%—further confirming the positive impact of the program.

In the control group, the Spearman correlation coefficient between the initial and final thoracic elasticity values also indicated a very strong positive relationship ($\varrho = 0.965$, $p < 0.0001$), suggesting stability in student rankings regarding thoracic mobility. Although no specific intervention was applied, the mean increase of 1.00 cm and the rise in students above average—from 30% to 80%—indicate a natural developmental trend, potentially influenced by routine physical education activities. However, the progress appears to be less consistent and less substantial compared to the experimental group.

In conclusion, the statistical and physiological data obtained from the evaluation of thoracic elasticity support the effectiveness of the applied kinetic program, reflecting tangible progress in respiratory function and thoracic mobility among 10–12-year-old children, with significantly better outcomes in the group that benefited from specialized intervention.

Discussion: the impact of athletics-based physical education on physical development

Consistency of developmental progress across somatic and functional parameters

The analysis of the Spearman rank correlation coefficients between initial and final assessments provides important insights into the internal consistency of developmental progress among students in both the experimental and control groups. Across all three measured parameters—height, weight, and thoracic elasticity—very strong positive correlations were observed, particularly in the experimental group, which followed a structured athletics-based physical education program.

The highest correlation was found for height in the experimental group ($\varrho = 0.994$, $p < 0.0001$), indicating exceptional stability in student rankings and suggesting a uniform and balanced growth process. Similarly, the correlation for weight was also extremely high ($\varrho = 0.993$, $p < 0.0001$), reflecting a consistent progression in body mass that aligns with individual ontogenetic rhythms. For thoracic elasticity, the correlation, though slightly lower ($\varrho = 0.975$, $p < 0.0001$), remained robust, supporting the effectiveness of the intervention in enhancing functional thoracic mobility in a homogeneous manner.

In comparison, the control group showed strong correlations as well—$\varrho = 0.992$ for height, $\varrho = 0.987$ for weight, and $\varrho = 0.965$ for thoracic elasticity—but with slightly lower values, indicating that while natural development occurred, it was somewhat less consistent and uniform than in the experimental group.

These findings underscore the role of structured physical education in promoting not only measurable improvements in physical parameters but also in ensuring a stable, harmonious developmental trajectory across a diverse student population

Educational relevance and theoretical validation

This empirical consistency in developmental progress serves as a foundation for broader This empirical consistency in developmental progress serves as a foundation for broader educational reflection. The findings of this study support the international consensus regarding the essential role of structured physical education during preadolescence, a period known for increased physiological plasticity and responsiveness to movement stimuli (Malina et al., 2015; Hill et al., 2024). By incorporating athletics into physical education, this research demonstrated notable improvements in key somatic indicators, specifically height, body weight, and thoracic elasticity. Such results highlight athletics exercises as effective pedagogical tools for fostering physical development in early adolescence.

The significant improvements noted in the experimental group confirm theoretical perspectives that describe physical education as a vital environment for enhancing organic growth and posture. For example, increases in height align with longitudinal research suggesting that appropriate and consistent physical activities stimulate growth hormone activity and skeletal development (Albaladejo-Saura et al., 2021; O'Brien et al., 2023; Malina et al., 2015; Willoughby & Hudson, 2023).

Greater thoracic elasticity improvements observed in the experimental group underline the advantages of rhythmic and cyclical exercises such as running and jumping. This finding is consistent with Thomas et al. (2020) and Wollesen et al. (2022) who emphasized that motor competence directly influences physiological efficiency and postural control during critical developmental stages.

Additionally, these outcomes align with the pedagogical approach advocated in the Romanian national curriculum (Ministry of National Education, 2017), which emphasizes athletics modules—Running, Jumping, and Throwing—as foundational components for skill development and overall physical growth.

To contextualize the current findings, several comparable studies involving Romanian children aged 11–12 have been examined. For example, Vorovenci (2019) explored somatic and psychomotor factors relevant to middle-distance running. Through standardized anthropometric and motor assessments, significant correlations emerged between endurance performance and explosive strength (standing long jump), trunk muscular endurance, and short-distance speed. These results reinforce our findings regarding the critical role of athletic-specific motor skills in improving overall physical capability.

Similarly, recent research by Tihulică emphasizes structured athletic programs' effectiveness when integrated into extracurricular activities for Romanian preadolescents. Focusing on endurance exercises, Tihulică (2024) observed significant improvements in aerobic capacity, muscular strength, and coordination, validated by enhanced Cooper test performances and middle-distance running (600–800 meters). This aligns well with our conclusions on the role of systematic physical activities in facilitating physiological development, particularly in cardiorespiratory fitness and muscular endurance.

Additionally, Gevat et al. (2012) provided comparative insights by examining physical abilities among Romanian and South African children. Their findings indicated that Romanian children performed better in technical and explosive strength tasks like the standing long jump, highlighting the effectiveness of Romania's athletic training within educational contexts. While acknowledging variations influenced by ethnic and cultural factors, Romanian participants consistently showed strong performance in physical skills supported by structured educational programs.

These complementary studies underscore our research's educational relevance and consistency, reinforcing athletics-based physical education as a highly effective pedagogical approach. Collectively, these findings affirm the importance of incorporating structured athletics activities into school curricula to enhance comprehensive physical development and promote sustained health among Romanian preadolescents.

Scientific contributions and practical implications

From a scientific standpoint, this study provides robust evidence for the effectiveness of low-complexity, high-frequency physical education interventions based on athletics. Unlike sport-specific training that targets performance outcomes, the program implemented here prioritized somatic growth, inclusivity, and pedagogical progression. This approach aligns with current calls for school-based programs that foster physical literacy rather than athletic specialization (Albaladejo-Saura et al., 2021; Di Maglie et al., 2022; Costa et al., 2021).

Key contributions include:

- Demonstrating that athletics-based content leads to statistically significant improvements in anthropometric variables;
- Providing a replicable model for low-cost, equipment-minimal physical education interventions;

- Reinforcing the interdependence between physical development and curriculum design, particularly when teaching strategies are adapted to developmental stages;
- Advocating for **a** broader educational vision of physical education, in which somatic growth is viewed as a core educational goal.

These findings are especially relevant in light of declining levels of physical activity among youth, as reported in recent global studies (Farooq et al., 2018). They are consistent with the findings of Barenie et al. (2025) and Jones et al. (2020) as well as with the 2024 guidelines of the World Health Organization, which emphasize the integration of daily moderate-to-vigorous physical activity into school environments as a strategy to counteract sedentary behavior and foster long-term health.

Limitations and future research directions

Despite its strengths, this study presents several limitations:

- The limited sample size and geographic concentration restrict the generalizability of findings;
- The lack of follow-up data limits understanding of the long-term effects of the intervention;
- The study focused on quantitative somatic indicators; future research should incorporate qualitative assessments such as postural screening, muscular symmetry, and functional movement evaluations;
- Variables such as dietary habits, sleep quality, and psychosocial environment, which may influence physical development, were not controlled.

Future studies should adopt a multidimensional assessment framework, combining biometric, functional, and behavioral data. Moreover, integrating wearable technology and digital feedback tools may enhance precision and motivation in physical education programs (Jopp 2019; Jastrow et al., 2022; Østerlie et al., 2025; Sousa et al., 2023).

Final considerations

This study confirms that athletics-based content can serve as an educational catalyst for somatic development in preadolescents when implemented through a pedagogically structured program. By focusing on general development rather than competitive results, physical education becomes a meaningful component of students' overall growth. Athletics exercises - due to their repetitive, measurable, and functional nature - create a predictable and safe context for physical evolution, which supports both educational objectives and public health aims.

The results validate athletics not only as a technical discipline but also as an integrated educational resource, reinforcing the broader mission of physical education: to shape healthy, autonomous, and physically literate individuals capable of maintaining well-being throughout life.

Conclusions

The present study confirms the formative potential of athletics-based physical education in supporting somatic development among lower secondary school students. The implementation of a structured, developmentally appropriate program focused on fundamental motor tasks—running, jumping, and throwing—led to statistically and pedagogically significant improvements in key physical parameters: height, body weight, and thoracic elasticity.

By aligning instructional content with students' biological and developmental characteristics, the intervention validated the hypothesis that regular and age-appropriate physical activity contributes meaningfully to growth and physiological regulation during preadolescence. These results echo recent research emphasizing the critical role of motor competence and physical activity in optimizing physical, cognitive, and psychosocial outcomes during early adolescence (Costa et al., 2021; Hill et al., 2024).

Several key conclusions can be drawn:

- Physical education, when structured in accordance with developmental science, plays a vital role in guiding biological growth, improving respiratory function, and ensuring harmonious body development during puberty.
- Athletics content offers an accessible, versatile, and pedagogically grounded platform for promoting physical literacy and postural efficiency without requiring specialized infrastructure or competitive objectives.
- The program is highly replicable in school settings, providing educators with a practical and evidence-based model for integrating health-oriented physical education into the curriculum.
- Athletics-based instruction fosters consistent progress through progression, repetition, and motivational feedback, promoting both physical self-efficacy and academic alignment.

Ultimately, this study reinforces the status of physical education not merely as a technical subject but as a core educational domain that cultivates health, resilience, and personal autonomy. Athletics, in this context, becomes more than a sport—it becomes a developmental tool contributing to the formation of physically literate, self-regulated, and health-conscious individuals.

In light of these findings, national and international curriculum developers are encouraged to strengthen the role of athletics within physical education programs, not only as a means of skill acquisition, but as a key strategy for supporting students' physical health, psychosocial development, and long-term well-being.

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Conflict of interest

The author declares that there are no commercial or financial relationships that could be construed as a potential conflict of interest in relation to this publication.

Author contributions

The author confirms sole responsibility for the conceptualization, design, data collection, analysis, interpretation, and writing of the present article. The final manuscript has been read and approved by the author.

During the drafting of this manuscript, I used ChatGPT 4.0, strictly as a language support tool. Its role was limited to assisting in the translation of text originally written by the author and enhancing the linguistic clarity and coherence of the manuscript. At no point was the tool used to generate ideas, structure the article, or interpret scientific content.

All research, data analysis, methodology, and conclusions are entirely my own. Every factual statement was independently verified and validated before submission.

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