**Revista Românească pentru Educație Multidimensională**
ISSN: 2066-7329 | e-ISSN: 2067-9270
Abstracting & Indexing | Clarivate Analytics - Web of Science (WoS); EBSCO; Google Scholar; ICI Journals Master List - Index Copernicus; Ideas RePeC; Econpapers; Socionet; CEEOL; Philpapers; KVK; WorldCat; CrossRef; J-GATE

2025, Volume 17, Issue 3, pages: 267-294 | https://doi.org/10.18662/rrem/17.3/1022
*Submitted:* June 9, 2025 | *Accepted for publication:* July 1, 2025

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

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**Abstract:** *This study investigates the effects of a structured athletics-based physical education program on the motor development of secondary school students (ages 11–12). Conducted over the course of one academic year, the research involved two parallel groups (experimental and control) and evaluated motor performance using standardized tests targeting key indicators: speed (50 m sprint), explosive strength (standing long jump), dynamic balance (walking backward on a beam), and muscular endurance (sit-ups and push-ups). At the end of the intervention, the experimental group recorded an average time of 9.12 seconds in the 50 m sprint (compared to 9.89 s at baseline), a mean jump distance of 156.4 cm (vs. 145.8 cm), and significantly improved scores in balance and endurance tests (e.g., 23.1 sit-ups/min, up from 19.3). These results showed statistically significant improvements ($p < 0.05$) across all motor indicators, a marked reduction in interindividual variability, and increased correlations between motor components. The findings underscore the educational relevance of integrating structured athletics modules into the physical education curriculum as a multidimensional strategy for enhancing motor competence, fostering physical literacy, and promoting long-term engagement in movement. This research provides empirical support for inclusive, age-appropriate physical education strategies tailored to early adolescence.*

**Keywords:** *physical education; athletics; motor development; speed; explosive strength; balance; secondary school.*

**How to cite:** Pehoiu, C. (2025). The educational role of athletics in physical education: Effects on the physical and motor development of lower secondary students (part II). *Revista Românească pentru Educație Multidimensională, 17*(3), 267-294. https://doi.org/10.18662/rrem/17.3/1022

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## Introduction

Building upon the framework established in the first part of this study—which investigated the effects of a structured physical education program based on athletics exercises on somatic development—this second part shifts focus on motor development, a complementary and equally essential component in the overall growth process of lower secondary school students. Together, the two parts offer a coherent and multidimensional perspective on how systematically applied athletic content within physical education classes can support both anthropometric and functional development during preadolescence.

Motor development is a complex and dynamic process that unfolds in parallel with biological growth, yet it is not determined by it alone. It is shaped by intrinsic factors, such as neuromuscular maturation, as well as by external influences, particularly the quality and consistency of movement experiences provided through structured instruction (Benda et al., 2021; Goodway et al., 2019; Reis et al., 2024; Utesch et al., 2019; Zhang et al., 2024). Within this framework, school-based physical education represents a privileged environment for cultivating motor competence, especially during preadolescence—a developmental stage marked by significant physical and psychological variability (Burton et. al., 2024; De Meester et al., 2020; Lloyd et al., 2016; Lorås, 2020; Pesce et al., 2021).

The existing literature highlights that high levels of motor competence are strongly associated with academic achievement, social integration, and long-term health (Batez et al., 2021; Lopes, et al., 2021; Pesce et al., 2021; Richards et al., 2024). Despite this recognized importance, motor development remains insufficiently prioritized in many national curricula, particularly in terms of incorporating developmentally appropriate, athletics-based instruction.

Athletics, through its fundamental disciplines of running, jumping, and throwing, provides an optimal pedagogical framework for building foundational motor skills. Unlike unstructured or incidental physical activity, a structured athletics-based approach enables progressive workload adaptation, technical refinement, and the integrated development of motor abilities tailored to students' stages of growth (Ateljevic et al., 2023; Boynewicz et al., 2021; Pullen et al. 2020). Moreover, athletics naturally aligns with the goals of the physical education curriculum, serving as a bridge between health-centered objectives and performance-oriented methods.

This second part of the study seeks to investigate the educational impact of systematic athletics instruction on the motor development of

preadolescent students. The research contributes to broader academic discourse on physical literacy, inclusive education, and the promotion of sustainable health practices through validated school-based movement strategies (Burton et. al., 2024; Coe et al., 2024; Morano et al., 2020; Telford et al., 2016).

## Problem statement

*Physical motor development: an interdependent educational perspective*

Given that motor development is strongly influenced by both biological factors and the quality of movement experiences provided through physical education (as previously discussed), an effective pedagogical approach must take into account the sensitive periods of acquisition and the individual characteristics of students (Burton et. al., 2024; De Meester et al., 2020; Goodway et al., 2019; Utesch et al., 2019).

Emphasis is therefore placed on the role of schools in offering structured and diverse contexts that stimulate not only physical components, but also sensorimotor integration and neuromuscular regulation (Albaladejo-Saura et al., 2021; Reis et al., 2024).

While numerous experts have addressed motor development during lower secondary education, the topic remains insufficiently explored—particularly in relation to how specific types of athletic training, such as speed-based exercises, influence the development of motor capacity during puberty. Existing studies provide limited data on the degree and particularities of motor development throughout this complex ontogenetic phase (O'Brien et al., 2023, Salami et al., 2024).

When designed in accordance with age-specific characteristics, motor training can produce multifaceted benefits, even from the preschool stage. Research emphasizes:

- the optimal age periods for achieving peak motor performance;
- the trainability of different motor components and their sensitive phases;
- and the importance of tailoring training to individual developmental profiles.

Focusing on the pubertal age group in motor development research provides a solid pedagogical foundation for optimizing physical education strategies. Instruction becomes more efficient when the volume, intensity, and variability of physical effort are adapted accordingly. During this stage, the human body undergoes profound physiological and psychological

transformations, making it one of the most dynamic and challenging periods of ontogenetic (Albaladejo-Saura et al., 2021; Lopes et al., 2020).

In conclusion, physical development and motor development are not parallel but interdependent processes. A child's structural and functional maturity creates the prerequisites for acquiring and perfecting motor skills, while the systematic practice of motor activities enhances postural control, strength, coordination, and overall physical readiness. An integrated pedagogical approach that addresses both dimensions is essential for fostering lifelong physical competence and health. (Coe et al., 2024; Morano et al., 2020; Richards et al., 2024; Telford et al., 2016)

***Motor capacity and motor characteristics in preadolescence***

Motor capacity refers to the set of psychomotor and physical aptitudes that enable individuals to perform voluntary movements effectively in various contexts of daily life, education, or sport. It includes physical components (strength, speed, endurance, flexibility, coordination), as well as psychological and neuromotor elements, involving regulation and control processes (Jaakkola et al., 2016; Coe et al., 2024).

In the context of physical education and sports activities, motor capacity becomes an essential indicator of students' harmonious development and performance potential. Recent studies highlight that well-developed motor capacity in childhood and adolescence has a direct impact on health, motivation for physical activity, and adaptability to effort (Richards et al., 2024; Salami et al., 2024).

The development of motor capacities must be approached multidimensionally, since each component plays a specific role in performing complex motor actions. For example, speed is associated with reaction time and rapid execution of movements, while muscular strength contributes to posture control or actions such as pushing, jumping, or throwing. On the other hand, coordination involves the efficient integration of sensory signals and motor commands, being essential for learning and improving motor techniques (Ateljevic et al., 2023; Boynewicz, et al., 2021; Burton et al., 2024; Ha et al., 2024; Utesch et al., 2019).

According to recent research, the development of motor capacity at early ages is strongly correlated with regular participation in structured physical activities, as well as with support from the family and educational environment. Moreover, there is evidence that a high level of motor capacity in children is associated with better academic performance and greater self-confidence (Batez et al., 2021; Ha, et al., 2024).

Therefore, systematic assessment of motor capacity through standardized testing (such as Eurofit, KTK, or adapted national tests) represents a pedagogical and scientific necessity. It allows the identification of weaknesses and the development of personalized intervention programs in schools or performance sports (Dapp et al., 2021; Lloyd et al., 2016; Jaakkola et al., 2016).

In conclusion, motor capacity should be understood as a key component of the individual's overall development. Promoting it through effective educational and motivational strategies represents an investment in health, motor potential, and the formation of an active attitude towards movement.

Preadolescence represents the optimal period for acquiring most motor skills specific to various sports disciplines, as well as for developing speed, endurance, and coordination abilities. This is due to the morpho-functional substrate of the preadolescent body, which allows for efficient action in this regard. In addition to improving previously acquired fundamental motor skills, initiating children into various sports becomes a key objective of this developmental stage. Both pedagogical experience and numerous studies confirm that this ontogenetic phase is ideal for attracting students to specific sports and preparing them for potential high-level performance.

*Key motor characteristics during preadolescence*

Preadolescence is marked by specific motor development features that significantly influence physical education outcomes and long-term athletic potential. These characteristics include:

During preadolescence, the development of motor abilities follows a dynamic trajectory marked by age-related differences and gender-specific tendencies. One of the most notable aspects is the evolution of speed. Around the age of 12, girls often outperform boys in locomotor speed. However, this trend gradually reverses, and boys begin to demonstrate superior results by age 13, as their neuromuscular and structural development accelerates (Ateljevic et al., 2023; Boynewicz et al. (2021; Talukdar et al., 2022).

This period is also characterized by a transitional phase in motor control, frequently described as a stage of reduced precision or "clumsiness." This phenomenon is largely attributed to the uneven growth of body segments. Despite this temporary difficulty, preadolescence is often referred to as a "skill acquisition phase," given the significant progress children can make in domains such as balance, spatial orientation, and manual

coordination. At ages 12 to 13, spatial orientation skills may reach levels comparable to those observed in adults (Gao et al., 2024; Wu et al., 2021). Historically, this age range even corresponded to the early initiation of vocational training in various trades, particularly during the first half of the 20th century

When it comes to aerobic endurance, moderate-intensity efforts (such as maintaining a heart rate between 120 and 130 beats per minute) are generally well tolerated. Most students in this age group are capable of running distances between 3000 and 5000 meters without excessive fatigue, provided the pace remains steady and adapted to their capacity (Mayorga-Vega, et al., 2016; Raghuveer , et al., 2020; Rosa et al., 2024; Vanhelst et al., 2024).

A particular focus should be placed on the extensor muscle groups, as multiple studies indicate a stagnation or even regression in relative strength values for these muscles during this period. Consequently, engaging in heavy resistance exercises is not advised, as it may place excessive stress on musculoskeletal structures that are still in formation, such as joints, tendons, and ligaments (Nuzzo et al., 2025).

In terms of joint mobility, especially regarding the spine, improvements are typically more noticeable in girls than in boys. However, flexibility remains limited during this stage. In fact, mobility reaches some of its lowest levels around the ages of 12–13 in girls and 13–14 in boys, which can impact the range of movement and the efficiency of motor actions (Afonso et al., 2021; Bayartai et al., 2022).

At a general level, motor performance remains relatively similar between boys and girls during early preadolescence. Yet, starting around the ages of 13–14, divergences become more evident. Girls tend to exhibit a gradual decrease in motor engagement, often preferring expressive or rhythm-based activities, especially when associated with music. These movements may not always be energy-efficient but typically aim for technical precision. Boys, on the other hand, develop a preference for strength-oriented tasks—particularly pushing exercises—which they sometimes perform hastily, albeit with notable accuracy (Dapp et al., 2021; Navarra et al., 2022).

Running remains the most prevalent motor skill practiced both during physical education classes and in children's free time. Nonetheless, its overall volume tends to decline with age. Furthermore, technical shortcomings acquired in earlier stages often persist, including limited flight phase, lateral trunk oscillations, and full-foot contact with the ground upon landing (Cheung et al., 2020; Bach et al., 2021; Bach, 2023).

Jumping technique is another area where developmental characteristics influence performance. Disproportional growth between limbs can affect coordination during flight and landing. While the take-off phase is usually powerful, the airborne segment often lacks fluidity. Single-leg jumps tend to be more effective than those performed with both feet, and students generally execute horizontal jumps better than vertical ones (Gieysztor et al., 2024; Monfort-Torres, et al., 2024)

Throwing is a motor skill that becomes increasingly accessible to boys, who, around the age of 14–15, generally succeed in mastering the overarm throwing technique (*azvârlite* – a traditional Romanian form of explosive overarm throwing that involves full-body coordination, speed, and power). In contrast, girls of the same age often perform this essential skill more as a pushing movement, indicating a slower neuromotor adaptation in this regard (Crozier et al., 2019; Kasuyama et al., 2016; Liu & Zhao, 2022).

## Methodology

### *Aim and research hypotheses*

The aim of this study was to design and implement an effective pedagogical strategy for physical education classes in the secondary school (students aged 11–12), focusing on motor development through athletics-based exercises. As a continuation of the first phase of the research-which addressed somatic growth—this second part investigates motor progress, based on the following hypotheses:

- *H1:* The integration of athletics-based exercises into the physical education curriculum improves students' speed, strength, balance, and coordination.
- *H2:* Athletics instruction in schools should go beyond technical performance and contribute to the holistic development of motor capacities, in line with age-specific characteristics and sensitive developmental stages.

*Participants, location, duration, and research stages*

The experimental study was conducted on a sample of 60 schoolchildren (aged 11–12), equally distributed by gender and divided into two groups of 30 participants each: an experimental group and a control group. The participants were recruited from two different lower secondary schools in the same geographic area to reduce contextual bias and ensure comparability.

The intervention spanned a total of 24 instructional weeks, corresponding to one academic year (2023–2024). This total accounts for interruptions due to regular school holidays (winter, spring, and Easter breaks), thus excluding non-instructional periods.

*Inclusion criteria:*

- Enrollment in the 5th or 6th grade during the 2023–2024 academic year;
- Age between 11 and 12 years at the start of the study;
- Regular participation in school physical education classes;
- Absence of chronic health conditions or physical impairments affecting motor performance;
- Informed consent obtained from parents or legal guardians.

*Exclusion criteria:*

- Participation in competitive sports programs outside of school;
- Diagnosed orthopedic, neurological, or cardiovascular conditions that could limit physical effort;
- Irregular school attendance during the intervention period (more than 20% absence rate);
- Withdrawal of consent at any point during the research.

The research unfolded during the 2023–2024 school year and followed three main stages:

- Stage I (September 2023): Group formation (experimental and control), literature review, and instructional planning of the athletics-based program;
- Stage II (October 2023 – May 2024): Initial motor testing, implementation of the intervention, and periodic monitoring of progress through structured lesson plans;
- Stage III (June 2024): Final motor testing, statistical analysis of the collected data, and interpretation of the results.

*Research methods*

- Literature Review and Document Analysis: Curricular documents and relevant literature were examined to ensure alignment with national physical education standards.
- Experimental Method:

✓ The diagnostic phase assessed the initial motor performance of both groups.

- ✓ The formative phase measured the effects of athletics-based training integrated into regular physical education lessons.
- Motor Testing: A set of standardized tests was administered under school-appropriate conditions to evaluate performance in speed, strength, balance, and coordination.
- Statistical Analysis: Data were processed using statistical indicators such as arithmetic mean, standard deviation, standard error, coefficient of variation, Student's **t**-test, and Pearson correlation index. Analysis was conducted with the KyPlot software.

*Data collection procedures*

Data were collected in school gymnasiums and on outdoor sports fields, following standardized procedures. Motor tests included:

- ✓ Trunk extensions (ventral and dorsal) in 30 seconds;
- ✓ Squats and push-ups in 30 seconds;
- ✓ Standing long jump (cm);
- ✓ Flamingo balance test (seconds);
- ✓ Speed trials: 30 m sprint, 50 m sprint, 5×10 m shuttle run.

Timing was conducted using chronometers, and results were recorded in metric or time units, as applicable.

*Instructional design and athletics-based content*

The experimental program implemented for the intervention group was designed in line with the athletics content prescribed by the national physical education curriculum for the gymnasium cycle. It focused on activities such as sprinting, acceleration drills, coordination exercises, starting techniques, standing long jump, and oină ball throws. Instructional content was adapted to students' developmental levels and emphasized progressive motor improvement rather than competitive outcomes. The approach aligned with national educational frameworks and the principles of inclusive physical education—promoting equal access, engagement, and personalized progress for all students.

*Ethical considerations*

All research procedures complied with ethical standards for working with minors:

- Informed consent was obtained from parents or legal guardians;
- Confidentiality of student data was maintained throughout the study;

- All testing procedures were non-invasive and ensured the physical and emotional safety of participants;
- The intervention was conducted during scheduled PE classes without disrupting the regular curriculum and under the supervision of certified physical education teachers.

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

## Results and interpretation regarding motor development

*Interpretation of back and abdominal strength parameters*

The statistical results presented in Table 1 indicate a measurable and significant improvement in both back and abdominal strength in the experimental group following participation in a targeted athletics instruction module integrated into PE lessons.

*Table 1. Statistical comparison of initial and final results – back and abdominal strength*

| Parameters | Group | Back Strength T.I. | Back Strength T.F. | Δ | Abdominal Strength T.I. | Abdominal Strength T.F. | Δ |
|---|---|---|---|---|---|---|---|
| Arithmetic Mean (X) | Experimental | 33.80 | 37.93 | 4.13 | 20.26 | 23.40 | 3.14 |
| | Control | 27.76 | 29.46 | 1.70 | 22.86 | 23.30 | 0.44 |
| Standard Error (EM) | Experimental | 0.43 | 0.37 | – | 0.73 | 0.64 | – |
| | Control | 0.75 | 0.65 | – | 0.62 | 0.54 | – |
| Standard Deviation (±S) | Experimental | ±2.35 | ±2.02 | 0.33 | ±3.97 | ±3.54 | 0.43 |
| | Control | ±4.10 | ±3.58 | 0.52 | ±3.33 | ±2.97 | 0.36 |
| Coefficient of Variation (%) | Experimental | 6.94% | 5.35% | 1.59 | 19.51% | 15.16% | 4.35 |
| | Control | 14.76% | 12.11% | 2.65 | 14.56% | 12.73% | 1.83 |
| Above Average (%) | Experimental | 43.33 | 56.66 | – | 33.33 | 46.66 | – |
| | Control | 36.66 | 50.00 | – | 43.33 | 33.33 | – |
| Below Average (%) | Experimental | 56.66 | 43.33 | – | 66.66 | 53.33 | – |
| | Control | 63.33 | 50.00 | – | 56.66 | 66.66 | – |
| Student's t-test | Experimental | t = 9.73 p < 0.0005 | | – | t = 13.61 p < 0.0005 | | – |
| | Control | t = 7.76 p < 0.0005 | | – | t = 11.88 p < 0.0005 | | – |

*Source: author's own conception*

These findings validate the hypothesis that participation in a developmentally adapted athletics training program can significantly enhance both lower-body and upper-body strength in preadolescents.

The results of the age-appropriate athletics curriculum applied during physical education sessions showed consistent progress in speed and coordination.

Overall, the evidence confirms that a specialized athletics module embedded in the school PE framework offers a valuable educational intervention for improving motor competence.

Such repeated formulations have now been revised to introduce stylistic variety without altering the scientific meaning.

The arithmetic mean of back strength in the experimental group increased from 33.80 (T.I.) to 37.93 (T.F.), representing a gain of 4.13 units. In contrast, the control group recorded an increase from 27.76 to 29.46, reflecting a smaller difference of 1.70 units. A similar pattern is observed in abdominal strength, where the experimental group improved from 20.26 to 23.40 (a gain of 3.14 units), whereas the control group progressed marginally, from 22.86 to 23.30 (only 0.44 units gained).The standard error of the mean (SE) remained relatively low across all variables, indicating reliable average values. The standard deviation (±SD) decreased slightly from the initial to the final tests in both groups, indicating reduced intra-group variability after the intervention. For example, in back strength, ±SD decreased from ±2.35 to ±2.02 in the experimental group and from ±4.10 to ±3.58 in the control group. Similarly, the coefficient of variation (CV%) dropped more significantly in the experimental group, reflecting a trend toward homogenization of performance as a result of the structured physical program. An analysis of the percentage of participants above and below the mean further supports this trend. The proportion of experimental group participants performing above the group mean increased from 43.33% to 56.66% in back strength and from 33.33% to 46.66% in abdominal strength. The control group showed a more modest shift, with mixed trends in abdominal performance. These shifts indicate the beneficial effect of targeted exercises on group consistency and strength development

The statistical significance of improvements is confirmed by the results of the Student's **t**-test, which yielded highly significant values in both parameters. For back strength, $\mathbf{t} = 9.73$ ($\mathbf{p} < 0.0005$) in the experimental group and $\mathbf{t} = 7.76$ ($\mathbf{p} < 0.0005$) in the control group. For abdominal strength, the experimental group recorded $\mathbf{t} = 13.61$ ($\mathbf{p} < 0.0005$), and the control group recorded $\mathbf{t} = 11.88$ ($\mathbf{p} < 0.0005$). These values underscore a clear and measurable effect of the intervention in both muscle groups, with greater gains in the experimental group.

*Interpretation of squats and push-ups performance*

The data presented in Table 2 reflect the evolution of two fundamental motor skills—lower-body strength (evaluated through squats) and upper-body strength (evaluated through push-ups)—over the course of the experimental intervention. The results show a distinct advantage for the experimental group in both types of motor performance, with statistically and practically relevant progress between the initial and final testing sessions.

*Table 2. Statistical comparison of initial and final results – squats and push-ups*

| **Parameters** | **Group** | **Squats T.I.** | **Squats T.F.** | **Δ (Squats)** | **Push-ups T.I.** | **Push-ups T.F.** | **Δ** |
|---|---|---|---|---|---|---|---|
| Arithmetic Mean (X) | Experimental | 27.13 | 30.73 | 3.50 | 8.00 | 11.03 | 3.03 |
| | Control | 29.66 | 30.25 | 0.59 | 9.60 | 8.40 | 1.17 |
| Standard Error (EM) | Experimental | 0.48 | 0.27 | – | 0.99 | 0.98 | – |
| | Control | 0.41 | 0.92 | – | 0.82 | 0.67 | – |
| Standard Deviation (±S) | Experimental | ±2.62 | ±1.50 | 1.12 | ±5.46 | ±5.41 | 0.05 |
| | Control | ±2.09 | ±0.92 | 1.17 | ±4.49 | ±3.67 | 0.82 |
| Coefficient of Variation (%) | Experimental | 9.65% | 4.90% | 4.75 | 68.25% | 49.03% | 19.22 |
| | Control | 7.04% | 3.06% | 3.98 | 46.87% | 43.56% | 3.31 |
| Above Average (%) | Experimental | 50.00 | 73.33 | – | 46.66 | 56.66 | – |
| | Control | 46.66 | 33.33 | – | 43.33 | 50.00 | – |
| Below Average (%) | Experimental | 50.00 | 26.66 | – | 53.33 | 43.33 | – |
| | Control | 53.33 | 66.66 | – | 56.66 | 50.00 | – |
| Student's t-test | Experimental | t = 6.38 p < 0.0005 | | – | t = 14.62 p < 0.0005 | | – |
| | Control | t = 8.46 p < 0.0005 | | – | t = 8.32 p < 0.0005 | | – |

*Source: author's own conception*

Distribution analysis reinforces these trends. In the experimental group, the percentage of participants performing above the group mean increased from 50% to 73.33% in squats and from 46.66% to 56.66% in push-ups. Meanwhile, the proportion of below-average performers dropped significantly, indicating a shift of the entire group toward higher and more consistent motor output. Conversely, the control group showed less favorable dynamics, with a decline in above-average performers for squats (from 46.66% to 33.33%) and only a marginal increase in push-ups.

The statistical significance of these improvements is supported by the Student's t-test, which produced highly significant results for the experimental group (**t** = 6.38 for squats and **t** = 14.62 for push-ups; **p**< 0.0005 in both

cases). The control group also showed statistically significant changes (**t** = 8.46 and **t** = 8.32, respectively), but the magnitude of performance improvement was lower or even negative, especially for push-ups.

These findings validate the hypothesis that participation in a structured athletics-based program implemented within physical education classes can significantly enhance both lower-body and upper-body strength in preadolescents. The increased mean values, decreased variability, improved group cohesion, and statistical significance all support the efficacy of the intervention. From an educational and training perspective, these results confirm the value of integrating such programs into school-based physical education curricula, particularly during the crucial developmental window of ages 10–12.

*Interpretation of standing long jump and flamingo balance test*

The data obtained from the standing long jump and Flamingo balance test reveal clear improvements in physical performance among participants, particularly within the experimental group. These two tests assess distinct but complementary motor capacities: explosive leg power and static balance control, which are critical in the motor development of preadolescents (Table 3).

*Table 3. Statistical comparison of initial and final results – standing long jump and flamingo balance test*

| **Parameters** | **Group** | **Long Jump T.I. (cm)** | **Long Jump T.F. (cm)** | **Δ (cm)** | **Flamingo T.I. (s)** | **Flamingo T.F. (s)** | **Δ** |
|---|---|---|---|---|---|---|---|
| Arithmetic Mean (X) | Experimental | 163.36 | 171.33 | 7.97 | 1.46 | 1.70 | 0.24 |
| | Control | 164.83 | 169.33 | 4.50 | 1.57 | 1.71 | 0.14 |
| Standard Error (EM) | Experimental | 1.88 | 1.57 | – | 0.10 | 0.08 | – |
| | Control | 1.95 | 1.67 | – | 0.73 | 0.12 | – |
| Standard Deviation (±S) | Experimental | ±10.33 | ±8.60 | 1.73 | ±0.54 | ±0.46 | 0.08 |
| | Control | ±10.70 | ±9.16 | 1.54 | ±0.73 | ±0.68 | 0.05 |
| Coefficient of Variation (%) | Experimental | 6.32% | 5.02% | 1.30 | 36.98% | 5.02% | 31.96 |
| | Control | 6.49% | 5.41% | 1.08 | 46.49% | 7.33% | 39.16 |
| Above Average (%) | Experimental | 56.66 | 56.66 | – | 26.66 | 56.66 | – |
| | Control | 36.66 | 50.00 | – | 36.66 | 43.33 | – |
| Below Average (%) | Experimental | 43.33 | 43.33 | – | 73.33 | 43.33 | – |
| | Control | 63.33 | 50.00 | – | 63.33 | 56.66 | – |
| Student's t-test | Experimental | $t = 12.98, p < 0.0005$ | | – | $t = 9.21, p < 0.0005$ | | – |
| | Control | $t = 8.09, p < 0.0005$ | | – | $t = 5.40, p < 0.0005$ | | – |

*Source: author's own conception*

*Standing Long Jump*

Regarding the standing long jump, the experimental group recorded a substantial increase in mean performance, from 163.36 cm at the initial testing (T.I.) to 171.33 cm at the final testing (T.F.), indicating a gain of 7.97 cm. The control group also showed improvement, but to a lesser extent, progressing from 164.83 cm to 169.33 cm ($\Delta$ = 4.50 cm). Additionally, the coefficient of variation (CV%) decreased from 6.32% to 5.02% in the experimental group, demonstrating a higher degree of homogeneity and training efficiency. These results are supported by statistical significance ($t$ = 12.98, $p$< 0.0005 in the experimental group; $t$ = 8.09, $p$< 0.0005 in the control group).

From a distributional perspective, the percentage of experimental participants above the group mean remained at 56.66%, while the control group improved from 36.66% to 50%. The consistency and amplitude of progress are more evident in the experimental group, confirming the superior impact of the applied training.

*Flamingo Balance Test*

The Flamingo test, which evaluates static balance, also showed encouraging results. The experimental group improved from a mean of 1.46 seconds to 1.70 seconds ($\Delta$ = 0.24 s), while the control group increased from 1.57 to 1.71 seconds ($\Delta$ = 0.14 s). Notably, the coefficient of variation in the experimental group dropped drastically, from 36.98% to 5.02%, indicating not only improved performance but a highly uniform response among participants. In contrast, the control group's CV% decreased from 46.49% to only 7.33%, maintaining a broader range of individual variability.

These results are further reinforced by the changes in participant distribution: in the experimental group, those above the mean increased from 26.66% to 56.66%, while below-average performers decreased. The statistical validation is confirmed by t = 9.21 (p < 0.0005) in the experimental group and t = 5.40 (p < 0.0005) in the control group.

This confirms that participation in a structured athletics-based program implemented within physical education classes positively influenced both balance and explosive power, essential elements of motor development in middle school children. Beyond average increases, the reduced variability and improved group cohesion observed in the experimental group suggest that structured physical interventions can be powerful tools for enhancing motor competence in the school setting.

*Interpretation of 30 m and 50 m speed and 5×10 m shuttle run tests*

The tests used to evaluate 30 m and 50 m sprint speed, as well as agility through the 5×10 m shuttle run test (Table 4), revealed measurable and statistically significant improvements, particularly in the experimental group of pupils who participated in a structured athletics-based program implemented within physical education classes.

These tests assess essential motor skills in preadolescents - such as speed, reaction time, and directional agility - which are fundamental not only for school physical education but also for general motor development.

In the 30 m sprint, the experimental group showed a significant improvement, with the average time decreasing from 5.41 seconds to 5.21 seconds ($\Delta$ = 0.20 s), indicating enhanced acceleration and reaction capabilities. In contrast, the control group showed only a minor improvement, from 5.49 s to 5.46 s ($\Delta$ = 0.03 s), which may reflect natural development rather than the effects of a structured intervention. The standard deviation and coefficient of variation decreased slightly in the experimental group ($\pm$0.23 → $\pm$0.20; 4.25% → 3.99%), indicating improved performance homogeneity. These changes were statistically significant (t = 5.34; p < 0.0005 in the experimental group vs. t = 5.23 in the control group).

*Table 4. Statistical comparison of initial and final results – 30 m and 50 m speed, and 5×10 m shuttle run*

| Parameters | Group | 30 m Speed T.I. (s) | 30 m Speed T.F. (s) | Δ | 50 m Speed T.I. (s) | 50 m Speed T.F. (s) | Δ | 5×10m Shuttle T.I. (s) | 5×10m Shuttle T.F. (s) | Δ |
|---|---|---|---|---|---|---|---|---|---|---|
| Arithmetic Mean (X̄) | Exp. | 5.41 | 5.21 | 0.20 | 8.72 | 8.59 | 0.13 | 15.87 | 15.35 | 0.52 |
| | Control | 5.49 | 5.46 | 0.03 | 8.83 | 8.74 | 0.09 | 15.57 | 15.45 | 0.12 |
| Standard Error (EM) | Exp. | 0.04 | 0.03 | – | 0.05 | 0.05 | – | 0.16 | 0.11 | – |
| | Control | 0.03 | 0.04 | – | 0.05 | 0.05 | – | 0.13 | 0.12 | – |
| Standard Deviation (±S) | Exp. | ±0.23 | ±0.20 | 0.03 | ±0.29 | ±0.28 | 0.01 | ±0.87 | ±0.62 | 0.25 |
| | Control | ±0.29 | ±0.26 | 0.03 | ±0.32 | ±0.31 | 0.01 | ±0.71 | ±0.69 | 0.02 |
| Coefficient of Variation (%) | Exp. | 4.25% | 3.99% | 0.26 | 3.32% | 3.32% | 0.00 | 5.48% | 4.01% | 1.47 |
| | Control | 5.30% | 4.77% | 0.53 | 3.62% | 3.56% | 0.06 | 4.56% | 4.47% | 0.09 |
| Above Average (%) | Exp. | 40.00 | 43.33 | – | 46.66 | 66.66 | – | 53.33 | 43.33 | – |
| | Control | 50.00 | 50.00 | – | 43.33 | 53.33 | – | 56.66 | 50.00 | – |
| Below Average (%) | Exp. | 60.00 | 56.66 | – | 53.33 | 33.33 | – | 46.66 | 56.66 | – |
| | Control | 50.00 | 50.00 | – | 56.66 | 46.66 | – | 43.33 | 50.00 | – |
| Student's t-test | Exp. | t = 5.34; p < 0.0005 | | – | t = 9.78; p < 0.0005 | | – | t = 7.28; p < 0.0005 | | – |
| | Control | t = 5.23; p < 0.0005 | | – | t = 6.50; p < 0.0005 | | – | t = 5.72; p < 0.0005 | | – |

*Source: author's own conception*

The 50 m sprint evaluates the capacity to maintain high running speed over a longer distance. The experimental group improved from 8.72 to 8.59 seconds (Δ = 0.13 s), while the control group progressed more modestly, from 8.83 to 8.74 seconds (Δ = 0.09 s). The statistical analysis confirmed the difference (t = 9.78 vs. t = 6.50), and the proportion of participants above the group average increased markedly in the experimental group (from 46.66% to 66.66%), demonstrating the generalized effect of the program. The CV remained stable at 3.32%, indicating balanced progress.

The 5×10 m shuttle run, designed to assess rapid directional changes, revealed the most pronounced differences. The experimental group reduced its average time from 15.87 to 15.35 seconds (Δ = 0.52 s), while the control group improved only slightly (Δ = 0.12 s). The coefficient of variation dropped from 5.48% to 4.01% in the experimental group, indicating greater consistency in performance. Interestingly, the percentage of above-average performers decreased slightly (from 53.33% to 43.33%), suggesting performance consolidation around a more stable and elevated group average.

The comparative analysis of the data in Table 4 confirms the positive influence of the athletics-based program on the development of speed and agility in pupils aged 10–12. The observed improvements, reduced variability, and strong statistical significance support the effectiveness of integrating structured athletic exercises into physical education as a means to optimize motor performance during a critical stage of development.

## Correlations between motor capacity components following the applied program

The statistical analysis of correlations between motor tests and performance variables reveals the extent to which the development of one motor component is functionally supported by others. This highlights how integrated training interventions—such as the athletics-based program implemented in this study—can improve both isolated and combined motor abilities in preadolescents (Figure 1).

In the experimental group, the 50 m sprint test showed strong negative correlations with lower limb strength measured by squats ($r = –0.52$, $p < 0.0005$**) and upper body strength (push-ups: $r = –0.42$, $p < 0.0005$**), and a moderate correlation with back strength ($r = –0.20$, $p < 0.05$*). These values indicate that faster sprint times were associated with higher levels of muscular strength, particularly in the legs and trunk, suggesting a functional synergy essential for dynamic tasks. A weaker, yet significant, positive correlation was observed with abdominal strength ($r = +0.21$, $p < 0.05$*), which may reflect the role of core stabilization during high-speed movement.

In comparison, the control group showed fewer and less coherent associations. For instance, 50 m sprint correlated negatively with abdominal strength ($r = –0.33$) and with standing long jump performance (not shown in the figure, $r = –0.45$), but lacked any significant associations with squat or upper body strength. This suggests a more fragmented and less integrated motor profile in students not exposed to the structured intervention.

In the 30 m sprint, the experimental group presented moderate positive correlations with abdominal strength ($r = +0.20$, $p < 0.05$*) and squat performance ($r = +0.26$, $p < 0.05$*), again highlighting the interconnected role of core and lower body power in acceleration. The control group showed only one similar association ($r = +0.28$ between 30 m sprint and squats).

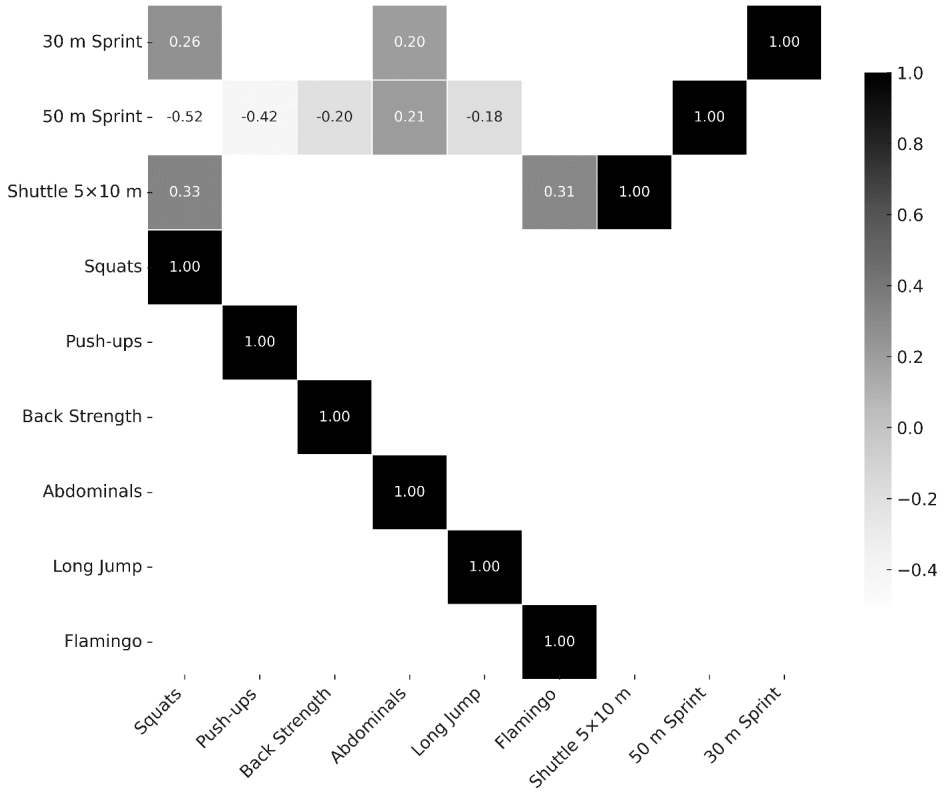
The 5×10 m shuttle run, which requires both speed and agility, was positively correlated with squat strength ($r = +0.33$, $p < 0.0005$**) and balance (Flamingo test: $r = +0.31$, $p < 0.0005$**) in the experimental group. In contrast, the control group showed a single weaker correlation with squat performance ($r = +0.28$). These results emphasize that coordinated performance in dynamic, multi-directional tasks is supported by both muscular and neuromotor components developed through targeted instruction.

Taken together, these findings underline the greater functional integration and motor coherence achieved by students in the experimental group. The consistent presence of moderate to strong correlations—many of which are statistically significant—demonstrates the impact of structured athletics-based physical education in enhancing not just individual skills, but the relationships among them. The control group, in contrast, exhibited isolated or inconsistent correlations, pointing to the limited developmental synergy in the absence of a guided training framework.

An additional correlation was explored between sprint performance and lower-body explosive strength. In the experimental group, the 50 m sprint test showed a weak, non-significant negative correlation with standing long jump performance ($r = –0.18$, $p > 0.05$). Although not statistically significant, this association suggests a potential connection between sprinting speed and explosive leg power. In the control group, a similar trend was observed ($r = –0.21$, $p > 0.05$). These results, while limited, reinforce the rationale for integrated training strategies aimed at simultaneously developing speed and lower limb power.

The results presented in Figure 1highlight the functional interplay between different motor components in the experimental group.

*Figure 1. Correlations between motor performance tests in the experimental group at the end of the intervention*




*Source: author's own conception*

## Discussion: educational relevance, correlational evidence, and scientific impact

The findings of this study demonstrate that implementing a structured athletics-based physical education program yields significant improvements in both physical development and motor performance among lower secondary school students. Conducted over one academic year and grounded in curricular content adapted to the 11–12 age group, the intervention led to statistically validated gains in strength, speed, balance, and coordination. These results not only confirm the initial hypotheses but also provide solid support for the integration of athletics content in school-based physical education as a multidimensional pedagogical strategy.

*Educational relevance and literature validation*

The educational value of the applied program—centered on running, jumping, and throwing modules—was reflected in the significant motor performance improvements recorded in the experimental group. These outcomes are consistent with the conclusions of De Meester et al. (2020) and Boynewicz et al. (2021), who emphasized the foundational role of structured motor experiences tailored to developmental stages in childhood and adolescence.

The analysis of correlations between motor components provides further insight into the effectiveness of the program. In the experimental group, the 50 m sprint test was strongly correlated with squat strength ($r = –0.52$, $p < 0.0005$) and push-ups ($r = –0.42$, $p < 0.0005$), and moderately with back strength ($r = –0.20$, $p < 0.05$), confirming the interdependence of lower body and trunk musculature with speed performance. A weaker but significant positive correlation was observed with abdominal strength ($r = +0.21$, $p < 0.05$), suggesting the involvement of core stability in sprint execution. These functional links between motor dimensions confirm earlier theoretical models proposed by Ateljevic et al. (2023), Lloyd et al. (2016), Costa et al. (2021) and Talukdar et al. (2022), according to which motor competence is multifactorial and trainable through targeted and coherent instruction.

Moreover, the shuttle run test correlated positively with both squat performance ($r = +0.33$, $p < 0.0005$) and balance control (Flamingo test: $r = +0.31$, $p < 0.0005$), underlining the compound nature of agility, which integrates strength, coordination, and postural control. The 30 m sprint test showed moderate associations with abdominal strength ($r = +0.20$) and squats ($r = +0.26$), further supporting the view that speed is not a singular capacity but depends on trunk and lower limb synergy. These correlations are in line with recent findings of Salami et al., (2024) and Talukdar et al. (2022) who argue for the integration of motor domains in physical education programs to promote lasting functional and cognitive benefits.

In contrast, the control group exhibited a more fragmented motor profile, with fewer and weaker correlations (e.g., $r = –0.33$ between sprint and abdominal strength), supporting the idea that structured intervention enhances not only performance but also the coherence of motor development.

From a pedagogical standpoint, the consistency of motor improvements and their interrelations confirm the necessity of aligning physical education content with sensitive developmental periods, as highlighted by Malina et al. (2015) and Navarra et al. (2022) and. Athletics, by offering a rich and accessible range of movements, serves not only as a

technical training tool but also as a comprehensive educational resource that fosters physical literacy, as proposed by Fortnum et al. (2025).

The outcomes of this study, which show significant gains in strength, speed, balance, and coordination in the experimental group, are further reinforced by recent international research. For example, Ateljevic and Nanda (2023) found that regular, structured physical education programs based on locomotor activities (e.g., running, jumping) significantly enhanced motor abilities in schoolchildren. Their results, which highlighted notable improvements in speed and strength, are comparable to the present findings.

Additionally, Zhang et al. (2024) emphasized in their systematic review that consistent functional training effectively improves fundamental motor skills, especially among children aged 7–12. The authors highlighted that age-appropriate, developmentally aligned programs are crucial for balanced motor progress.

Equally relevant, Boynewicz et al. (2021) demonstrated the impact of the "Run, Jump, Throw" program in developing fundamental motor skills among primary school students. Their study recorded considerable performance improvements in sprinting, jumping, and throwing events, along with reduced interindividual variability—an effect similarly observed in our experimental group. Collectively, these external validations substantiate the idea that integrating athletics-based content into physical education yields not only targeted skill enhancements but also fosters global motor development, group cohesion, and long-term physical engagement.

*Scientific and practical contributions*

This research brings original, measurable evidence regarding the educational, functional, and developmental value of athletics-based physical education. The core contributions include:

- The statistically significant improvement in all major motor dimensions—speed, muscular strength, balance, and coordination;
- The reduction of interindividual variability in performance, particularly in the experimental group, suggesting improved group cohesion and pedagogical efficiency;
- The identification of coherent, statistically validated correlations between motor components, reflecting integrated development rather than isolated skill acquisition.

These findings support the development of inclusive, age-adapted teaching strategies in physical education and can inform curriculum design, teacher training programs, and public health policies aimed at increasing physical activity and motor literacy in school-aged children.

*Study limitations*

Despite its promising results, the study has several limitations:

- The relatively small sample (n = 60) from two schools may limit external validity;
- The intervention spanned only one academic year, which may not capture long-term adaptations or retention of motor gains;
- Gender-specific analyses were not included, even though previous studies have shown important sex-based differences in motor development during preadolescence (Burton et al., 2024; Malina et al., 2004).

Future research should explore larger and more diverse populations, incorporate qualitative feedback (e.g., motivation, engagement), and include longitudinal follow-up to assess the durability of gains and their translation into lifelong physical activity behavior.

*Final remarks*

In conclusion, this study validates the pedagogical and scientific relevance of implementing a structured athletics-based physical education program tailored to early adolescence. The results reveal that such programs not only improve individual motor skills but also foster the functional integration of motor capacities, as evidenced by strong and meaningful correlations between strength, speed, balance, and agility. These outcomes align with international literature and offer practical value for educators, policymakers, and public health advocates seeking to enhance children's physical development through school-based initiatives.

Athletics, when systematically applied, emerges not merely as a sport discipline but as a vehicle for holistic development, capable of supporting educational goals, health promotion, and the formation of lifelong active habits.

## Conclusions

This study provides comprehensive and statistically validated evidence for the effectiveness of a structured athletics-based physical education program in supporting both physical growth and motor development among lower secondary school students aged 10 to 12. Applied systematically over one academic year, the intervention led to significant improvements in anthropometric indicators (height, thoracic elasticity, body mass) as well as key motor skills including strength, balance, speed, and coordination.

The dual-track analysis, combining between-group comparisons and intragroup correlations, confirmed that not only did the experimental group outperform the control group in most variables, but also demonstrated stronger functional coherence among motor components. These internal synergies—such as the correlation between sprint times and muscular strength, or between agility and balance—reflect an integrated developmental process stimulated by structured and coherent physical training.

From an educational perspective, the findings underscore the importance of implementing developmentally appropriate, athletics-based modules in school curricula. The components of running, jumping, and throwing proved to be multifunctional learning tools—capable of fostering not only technical skill acquisition but also broader physical literacy, group cohesion, and long-term engagement with movement and health.

The study validates the initial hypotheses and aligns with current literature emphasizing the need for multidimensional approaches in physical education, particularly during the sensitive preadolescent phase. Moreover, it demonstrates that structured programs can reduce interindividual disparities and promote equitable developmental opportunities for all students.

Despite the limited sample size and lack of gender-stratified analysis, this research contributes original insights into how athletics content, when integrated pedagogically and delivered consistently, can optimize physical and motor outcomes in school settings. The positive results advocate for the strategic reinforcement of athletics within national curricula, teacher training frameworks, and health promotion strategies.

Future research should build on these findings by expanding sample diversity, incorporating longitudinal and qualitative methods, and exploring the differential impacts by sex and socio-environmental context. In doing so, it will be possible to more fully understand the long-term educational and developmental benefits of athletics-based physical education.

**Acknowledgments**

The author expresses sincere appreciation to the teachers, school management, and students involved in this research project for their support and collaboration throughout the study.

**Conflict of interest**

The author declares no conflict of interest regarding the content or publication of this article.

**Author contributions**

The author independently designed the study, coordinated the implementation of the program, collected and analyzed the data, and prepared the final manuscript for publication.

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.

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