

A study on lower limb explosive strength and its correlation with speed and coordination in elementary school children in Tirana.

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Published online: May 31, 2025

Accepted for publication: May 15, 2025

DOI:10.7752/jpes.2025.05106

Abstract

Globalization, which initially began in the commercial sector, has influenced many aspects of human behavior, including motor behavior. A significant global decline in physical activity has been observed, affecting individuals from early childhood, including preschool age. This study aims to investigate the explosive strength of the lower limbs in elementary school children and its correlation with speed and coordination, in order to better understand children's physical capabilities and evaluate the impact of physical activity in schools on their development. The main objective of this study was to compare lower limb explosive strength and speed-agility performance between boys and girls in the second and third grades of elementary schools in Tirana. Additionally, the study examined the correlation between explosive strength and agility. A total of 120 children from Tirana participated in the study, including 64 boys and 56 girls; among them, 36 boys and 24 girls were in the second grade, and 28 boys and 32 girls in the third grade. The tests conducted were the long jump, 20-meter sprint, and 10x5 meter agility test. Descriptive statistics (mean and standard deviation) were calculated, and independent sample T-tests were used to compare variables between boys and girls, using SPSS 20.0 software. Results indicate a significant correlation between lower limb explosive strength and speed-agility performance, highlighting the importance of developing explosive strength to improve coordination and speed in children.

Keywords Physical activity, motor behavior, agility, lower limb, explosive strength

Introduction

Gross motor skills are generally easier to develop than fine motor skills because they involve large, general movements that are more visible and easier to practice and learn (Sekulic, D., et al., 2014). In contrast, fine motor skills involve small, precise movements of the muscles, particularly those in the hands and fingers (Santos, E. J., et al., 2015; Chaouachi, A., et al., 2014). Both gross and fine motor skills are essential for everyday functioning and the acquisition of sport-specific abilities (Lopes, V. P., et al., 2016). These types of motor skills are interdependent and tend to develop in parallel, with gross motor skills typically maturing earlier (Robinson, L. E., et al., 2015).

Specific motor skills evolve from these foundational motor abilities and are directly related to particular sports or physical activities (Kenney, W. L., et al., 2015). These skills typically begin to emerge and develop significantly during adolescence, particularly between the ages of 13 to 15 years (Maes, H. H., et al., 2016), when motor abilities become more refined. Gross motor skills during this period become more complex and coordinated (Stults-Kolehmainen, M. A., & Sinha, R., 2014). By the age of 16 to 18 years, improvements in motor coordination, precision, and movement control are particularly evident.

Muscular strength is defined as the capacity of muscles to generate force, while muscular power refers to the ability to produce that force rapidly (Phillips, S. M., 2014; Kraemer, W. J., et al., 2017). Aerobic capacity, or cardiorespiratory endurance, is the ability of the body to transport and effectively utilize oxygen during sustained physical activity (Lloyd, R. S., et al., 2016). For children, a well-developed aerobic capacity is crucial for cardiovascular health (Ericsson, I., 2017) and enhances performance in endurance-based sports such as running and swimming. Flexibility, defined as the ability to move a joint or series of joints through a full range of motion, is another key component of physical fitness (McArdle, W. D., et al., 2017). In children, flexibility aids in motor development and supports participation in sports requiring large ranges of motion, such as gymnastics (Janssen, I., et al., 2015).

Motor coordination refers to the ability to synchronize different parts of the body to perform smooth and efficient movements (Payne, V. G., & Isaacs, L. D., 2017). It is fundamental for acquiring basic motor skills such as running, throwing, or balancing. Agility, or the ability to move quickly and change direction with ease, enhances children's responsiveness in various physical situations.

The development of motor skills is closely linked to the biological processes of growth and maturation in children. As their bodies grow and change, their physical abilities naturally evolve. Psychological development, including perceptual skills and self-awareness, also plays a critical role in motor performance. Nutrition significantly influences motor development by supporting muscle growth, energy levels, and brain function. Environmental factors, particularly physical activity, are major contributors to motor skill advancement. Children who are more physically active tend to improve their motor skills faster than those who are less active (Pate, R. R., et al., 2019). Furthermore, those who engage in structured training or play activities requiring motor precision typically experience greater improvements.

Regular physical activity enhances coordination, strength, and reaction speed, resulting in stronger overall motor performance. A study by Haapala, E. A., et al. (2015) found that children participating in physical activities during school hours exhibit better motor skills than their less active peers. Similarly, Naylor, P. J., et al. (2018) demonstrated that physically active children perform better in tasks requiring concentration, visual processing, and hand-eye coordination. Participation in various sports, games, and engaging physical exercises supports holistic motor development. Strength, defined as the capacity to perform work against resistance, is essential for high-intensity actions such as lifting or pushing. For developing maximal strength, exercises with heavy loads and low repetitions (1–5 reps at 85–100% of one-repetition maximum) are most effective.

Muscular endurance, or resistance strength, is vital for sustained physical efforts. It is best developed through high-repetition, moderate-intensity exercises (12–20 reps) with minimal rest intervals. Explosive or quick strength, also referred to as dynamic strength, is the capacity to produce force in a short time frame and is essential for rapid or powerful movements. Maximal strength is particularly important in tasks requiring the application of significant force. Finally, chronic stress and insufficient rest can impair muscle development and overall motor progress in children, underscoring the importance of balanced training and adequate recovery.

Methodology

Research Design

A total of 120 children (students) were randomly selected for testing, including 36 boys and 24 girls from the second grade, and 28 boys and 32 girls from the third grade. The tests were conducted in the school gymnasium in the city of Tirana. The physical performance tests administered included the standing long jump, 20-meter sprint, and the 10x5 meter shuttle run.

All tests were carried out during the physical education class in the early morning hours, under standardized conditions, using calibrated measuring instruments in a well-lit environment. A team of two individuals conducted the testing procedures: one was responsible for taking measurements, and the other for recording the results.

Prior to the start of testing, children were thoroughly informed about the procedures and the correct execution of each test. During testing, measurement results were announced immediately, and for the purpose of accuracy, the person recording the data repeated the results aloud to ensure no errors occurred.

At the end of the testing session, the collected data for each student were entered into a database and prepared for statistical analysis.

Description of measuring instruments: The measurements were carried out using the following tools:

1. Brower Timing Systems.
2. Carpeted Long Jump Mat (marked with centimeters and millimeters).
3. Stopwatch.
4. Brower Timing Systems

The Brower Timing Systems apparatus was used to test running speed over a 20-meter distance.

In our study, we used 4 (four) devices, with 2 (two) placed at the start and 2 (two) at the finish to measure the running time over the 20-meter distance. (fig.1)

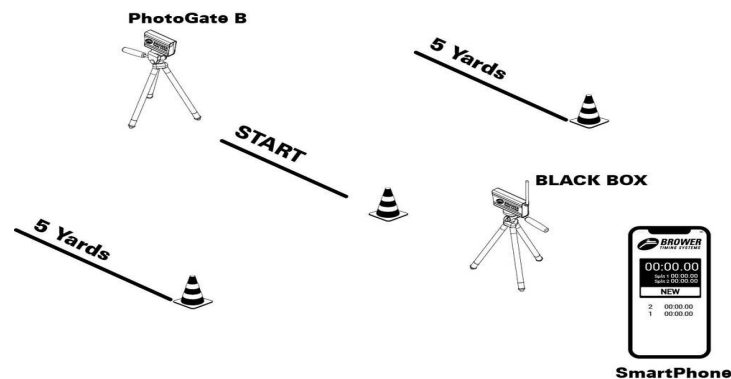


Figure 1. Presentation of the Brower Timing Systems apparatus

Test Description According to the Protocol

20 Meter Sprint Test

The 20-meter sprint test is a physical test used to assess a person's speed over a distance of 20 meters (fig.2). The development of this test follows specific steps:

1. **Preparation:** One of the measurers places two cones at a distance of 20 meters. They prepare the Brower Timing Systems device for time measurement.
2. **Positioning:** The student positions themselves at the starting cone and takes the starting stance.
3. **Start Running:** When the measurer positioned at the apparatus gives the signal to start, the student runs as fast as they can towards the finish cone (20 meters away).
4. **Measuring Results:** The result is automatically measured by the device and recorded by the measurer. The test was performed 3 (three) times, and the best value was recorded.



Figure 2. Presentation of the 20-meter sprint test.

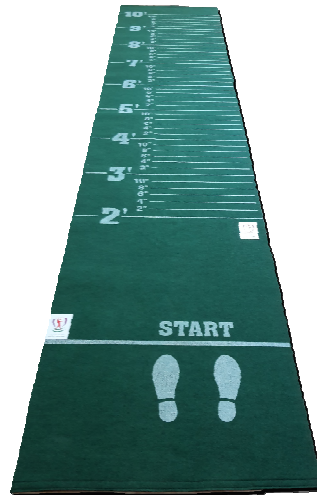


Figure 3. Presentation of the Carpeted Long Jump Mat

The Carpeted Long Jump Mat (fig.3) was used for testing the long jump. This mat is made of a carpet-like material with a soft surface and marked sections to assist in measuring the jump distance. The markings are in centimeters. This equipment provides a standardized and accurate method for measuring the distance of a jump in activities such as long jumping.

Long Jump Test

The long jump test is used to assess the explosive strength of the leg muscles in children (fig.4). The development of this test follows specific steps:

1. **Preparation:** The children are placed on a flat and stable surface in the gym area. They position their feet together in a comfortable stance and prepare to perform the jump.
2. **Placing the Carpeted Long Jump Mat:** The mat is placed on the ground in front of the children's feet. This will serve as a reference point to measure the distance they achieve during the jump.
3. **Jumping:** The children are instructed to bend their knees with their arms extended in front of them, parallel to the ground. They then swing both arms, push as strongly as possible, and jump as far as they can. Using the strength of their leg muscles, the children perform a jump aiming to reach as far as possible. They make a full effort to achieve a strong and controlled jump.
4. **Measuring Results:** The result is measured by evaluating the distance from the starting point of the mat to the mark left by the heel. Two measurers were positioned: one near the starting line, giving the command to start the test, and the other at the end, recording the distance achieved. The test was conducted 3 (three) times, measured in centimeters, and the best value was recorded.



Figure 4. Presentation of the Long Jump Test

Stopwatch

Use of the Stopwatch The stopwatch was used to measure the 10x5 m test. A stopwatch is a device used to measure time.

10x5 m Speed and Coordination Test

The 10x5 m test is used to evaluate speed, coordination, and the duration of children by performing directional changes between two points set at a specified distance (fig.5). The test consists of 10 movements in the forward direction (from point A to point B) and then returning after each movement.

2.3 Test Procedure:

1. Place two cones, A and B, 5 meters apart.
2. The children start at cone A and prepare to begin the test.
3. A signal given by the measurer indicates the start of the test.
4. The children perform 10 quick movements from cone A to cone B, trying to minimize the time needed for each movement.
5. After each movement, the children return to cone A to start the next movement.
6. The total time of the test, measured with a stopwatch, is recorded and noted by the measurer.



Figure 5. Presentation of the 10x5 shuttle Test Agilit (Speed and Coordination)

Statistical Analysis

Based on the experimentation, study, and the results obtained from physical tests and their analysis using SPSS 20.0, including mean, standard deviation, regression equation, and correlation, we have reached the following conclusions. The linear regression equation attempts to approximate the value of one variable based on another variable. In our case, we aim to approximate the value of agility based on the strength of the lower limbs.

After constructing the equation, we presented the results graphically in the discussion section below, where the regression equation is represented by green lines. This clearly shows our objective. Using our variables, we calculated and studied the relationship between them using the concept of correlation.

Correlation is the linear relationship between two variables, calculated using a statistical formula by inputting the values of these two variables and yielding a single coefficient, known as the correlation coefficient.

Results

Table 1 Descriptive Statistics Grouped by Gender and Class

Class		Gender	Students' number	Mean	Std. Deviation	Std. Error Mean
2nd grade	20 m Sprint	Boys	36	5.59	0.59	0.1289
		Girls	24	5.84	0.63	0.1143
	Long jump	Boys	36	105.39	8.52	3.4999
		Girls	24	94.8	7.86	2.7714
	10x5 m shuttle test	Boys	36	9.83	1.04	0.6654
		Girls	24	9.97	0.55	0.4555
3rd grade	20 m Sprint	Boys	28	5.17	0.42	0.1668
		Girls	32	5.89	0.37	0.1646
	Long jump	Boys	28	129.54	5.71	3.2537
		Girls	32	110.23	5.23	2.5421
	10x5 m shuttle test	Boys	28	10.28	1.08	0.5045
		Girls	32	10.06	0.55	0.4667

In Table 1, we present the results of the mean, standard deviation, and standard error of the mean grouped by gender and class.

Table 2 Descriptive Statistics by Male Gender (Boys) and Class

Boys					
Class		Students' number	Mean	Std. Deviation	Std. Error Mean
2nd grade	20 m Sprint	36	5.59	0.59	0.1289
	Long jump	36	105.39	8.52	3.4999
	10x5 m shuttle test	36	9.83	1.04	0.6654
3rd grade	20 m Sprint	28	5.17	0.42	0.1668
	Long jump	28	129.54	5.71	3.2537
	10x5 m shuttle test	28	10.28	1.08	0.5045

Tables 2 and 3, the database of the data collected from our measurements is presented in more detail. Table 2 provides data only for boys, while Table 3 presents the same measurements but for girls.

Table 3 Descriptive Statistics by Girls Gender (girls) and Class

Girls					
Class		Students' number	Mean	Std. Deviation	Std. Error Mean
2nd grade	20 m Sprint	24	5.84	0.63	0.1143
	Long jump	24	94.8	7.86	2.7714
	10x5 m shuttle test	24	9.97	0.55	0.4555
3rd grade	20 m Sprint	32	5.89	0.37	0.1646
	Long jump	32	110.23	5.23	2.5421
	10x5 m shuttle test	32	10.06	0.55	0.4667

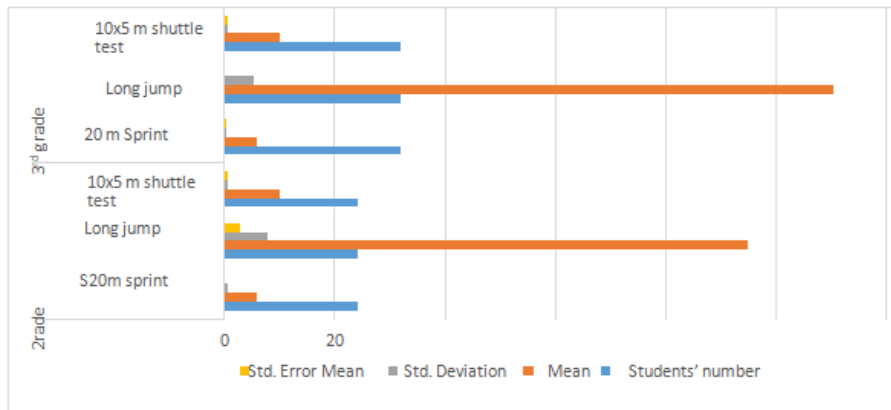


Figure 6 (Graph 1): Provides comparative data for the male gender (boys) between grades.

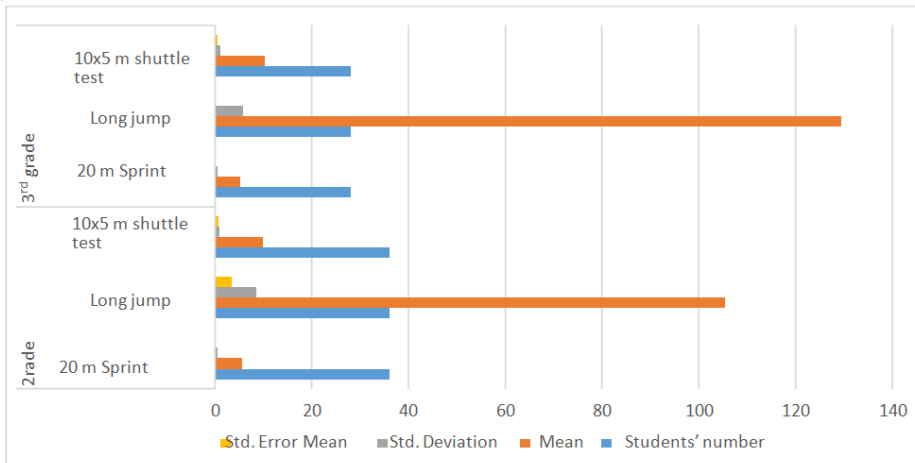


Figure7 (Graph 2): Provides comparative data for the girl gender (girls) between grades.

From Table 4(below), we observe that the relationship between the variable strength, measured through the long jump test, and the variable agility, measured through the 10x5 m test, shows a nearly strong positive correlation (0.56342). This indicates that an increase in the strength parameter significantly impacts the increase in the agility parameter.

The relationship between the strength variable, measured by the long jump test, and the agility-speed variable, measured by the 20 m sprint test, also shows a nearly strong positive correlation (0.4364).

Tab 4 Pearson Correlation between Strength and Agilit

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		c 10x5m.		20-meter sprint
long jump (strength)		0.56342		0.4364

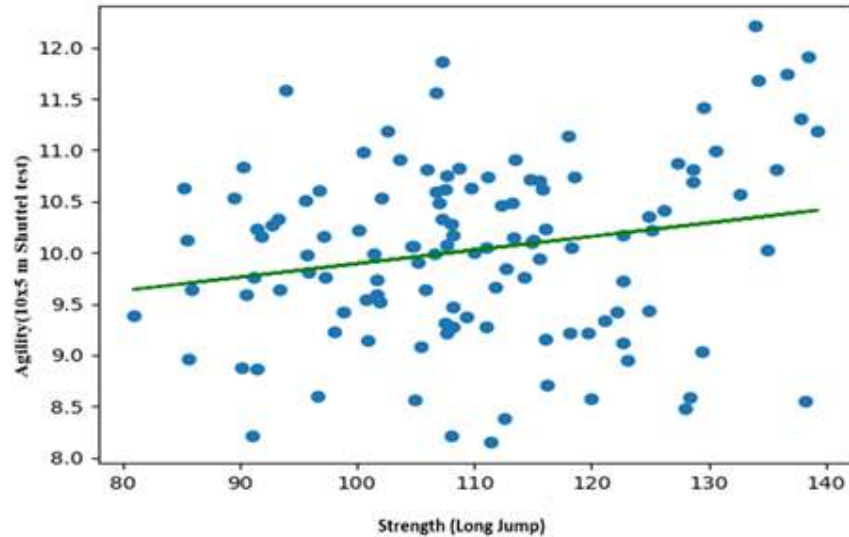


Fig 8 Regression Equation for the Variables Strength (Long Jump) and Agility(10x5 m Shuttle test)

From this analysis, we conclude that the variables have a positive relationship and are closely linked, meaning that they are strongly related to each other. As one increases, the other also increases. To demonstrate how the agility component changes in relation to the lower limb strength component, we constructed linear regression equations.

We observe that in the equation presented in the graph of Figure 8, the coefficient is slightly distinguishable, indicating that the lower limb strength component, measured by the long jump test, shows a trend of increasing agility with the increase in lower limb strength.

The regression analysis between explosive strength, measured by the standing long jump, and agility, measured by the 10x5 m shuttle run, reveals a positive relationship between these two variables. The regression equation is:

$$Y(\text{agility}) = \beta_0 + \beta_1 \times X(\text{Explosive Strength}) + c$$

$$\text{Agility} = 8.92 + 0.0102 \times \text{Explosive Strength}$$

This means that for every 1 cm increase in explosive strength (as measured by the long jump distance), agility performance (represented by the time taken to complete the 10x5 m shuttle run) improves by 0.0102 seconds. The intercept of 8.92 indicates the estimated agility performance when the explosive strength is zero, though this is a theoretical value. The positive coefficient m suggests that greater explosive strength is associated with better agility performance, confirming the hypothesis that leg power has a beneficial impact on speed and agility.

Discussion

From the analysis of the data presented in Table 1, it is evident that the 20-meter Sprint test shows the lowest average time for boys in the third grade, followed by boys in the second grade, girls in the second grade, and girls in the third grade. This indicates that boys are faster than girls, despite the one-year age difference. The standard deviation is closer to the mean for both boys and girls in the third grade, suggesting less variation within those groups.

- The standard error of the mean, which reflects the precision of the sample mean estimate, is lower for both girls and boys in the second grade. This is also observed in the Shuttle test for third and second grades, and in the Long Jump test for the second grade.
- In the Long Jump test, the highest average was recorded by boys in the third grade, followed by girls in the third grade, boys in the second grade, and girls in the second grade. This suggests that boys possess greater explosive strength in the lower limbs compared to girls. Additionally, girls in the third grade demonstrate greater explosive strength than girls in the second grade.
- The standard deviation in this test is also closer to the mean for boys and girls in the third grade, indicating more consistent performance. Furthermore, the standard error of the mean is lowest for boys and girls in the third grade, showing higher precision in the data for this group.
- In the 10x5 meter Shuttle Run test (Tables 2 and 3), the lowest average time was observed for boys in the second grade, followed by girls in the second grade, girls in the third grade, and boys in the third grade. This leads to the conclusion that second-grade students are more agile than those in the third grade. The standard deviation is closer to the mean for girls in both the second and third grades, as well as for boys in the third grade. The standard error of the mean is lowest for girls in both the second and third grades, indicating greater reliability in the average values.
- In Table 2, the results for the mean, standard deviation, and standard error of the mean are presented in detail. The lowest standard error of the mean was observed in the 20-meter Sprint test for the second grade, the Long Jump test for the third grade, and the 10x5 meter Shuttle Run test for the third grade. When analyzing all the tests together, the Long Jump test in the third grade had the lowest standard deviation, followed by the 20-meter Sprint test in the second and third grades, the Shuttle test in the third and second grades, and the Long Jump test in the second grade.

Graphical Interpretation

- In Figure 6 (Graph 1), the average performance in the agility test is lower for second-grade students, indicating higher agility. In the Long Jump test, the average is higher for third-grade students, showing improved lower limb strength. For the 20-meter Sprint, the average is lower for second-grade students, suggesting higher speed. These results confirm that girls in the third grade have greater lower limb strength than those in the second grade, whereas girls in the second grade are faster and more agile than their older counterparts.

Regarding the standard error of the mean, it is lower in the 20-meter Sprint tests and higher in the Long Jump test for the second grade.

- In Figure 7 (Graph 2), the data points are closely clustered around the regression line, indicating linearity and a strong relationship between the variables. This suggests a consistency in agility performance as strength increases.

Since the regression line has a positive slope and its coefficient is greater than zero, it confirms a positive linear relationship between lower limb strength and agility: as strength increases, agility also improves.

Using the variables in our study, we calculated the relationship between them through correlation analysis. The correlation coefficient ranges from +1 to -1, where:

- Values from -1 to -0.7 indicate a strong negative relationship.
- Values from -0.7 to -0.3 indicate a moderate negative relationship.
- Values from -0.3 to 0 indicate a weak or no negative relationship.
- Values from 0 to 0.3 indicate a weak or no positive relationship.
- Values from 0.3 to 0.7 indicate a moderate positive relationship.
- Values from 0.7 to 1 indicate a strong positive relationship.

This research highlights that boys have greater lower limb strength compared to girls, which allows them to perform better in long jump tests. Interestingly, despite this physiological advantage, girls demonstrate greater agility in certain aspects, particularly in the 10x5 meter shuttle test. Studies by **Naylor, P. J., et al. (2015)** showed similar findings in elite basketball players, where agility was more closely related to sprint and jump performances in male athletes. However, the current study's novelty lies in focusing on elementary school children and emphasizing the agility advantage of girls despite their lower strength levels.

The study found a strong positive correlation ($r = 0.56342$) between lower limb explosive strength (measured by the long jump) and agility (measured by the 10x5 meter shuttle test). This suggests that as explosive strength increases, agility improves. Tomkinson, G R., et al. (2019) explored similar correlations in older populations (adolescents) and found that improvements in explosive strength through plyometric training positively impacted agility. However, the novelty of this study lies in its focus on younger, elementary-aged children, providing new insights into early physical education and development.

There was also a positive correlation ($r = 0.4364$) between strength (measured by the long jump) and agility speed (measured by the 20-meter sprint test). Boys generally exhibited higher speed in the sprint test compared to girls, but girls displayed better performance in agility-related tasks. Pinoniemi, B. K., et al. (2019) focused on agility testing in children and found similar results, where agility performance improved with

increased strength. However, this study introduces a key discussion about gender-specific agility advantages in young girls, which previous research had not extensively covered.

One of the unique contributions of this study is the emphasis on how structured physical education (PE) programs positively affect both strength and agility development. It suggests that regular PE sessions improve motor skills from an early age, which could have long-term benefits on children's athletic development. (While Barboza, C. F. S., et al .2020) focused on the impact of physical education in schools on overall child development, particularly motor skills and cognitive outcomes, this study emphasizes a specific link between structured school-based PE programs and motor skill development in a younger population.

Conclusion

The study makes important contributions by examining gender differences in strength and agility, as well as highlighting the importance of structured physical education programs in developing motor skills in elementary school children. While it confirms existing research regarding the positive relationship between explosive strength and agility, its focus on younger children and the detailed gender-based comparison adds a unique dimension to the field of motor behavior research.

The male gender (boys) exhibits greater lower limb strength than **the female gender (girls)**, enabling them to achieve longer distances in the long jump test. This physiological difference is supported by existing literature.

The male gender (boys) demonstrates higher speed compared to **the female gender (girls)**, completing the 20-meter sprint test in a shorter time than girls. This speed difference is attributed to higher explosive strength in the lower limbs among boys compared to girls, as indicated in the literature.

Comparing two age groups within the **female gender (girls)**, we found that second-grade girls are more agile and faster than third-grade girls, despite third-grade girls having greater lower limb strength.

Comparing two age groups within the **male gender (boys)**, we concluded that third-grade boys have greater lower limb strength and are faster compared to second-grade boys. Conversely, second-grade boys are more agile than third-grade boys.

The regression equation confirms a direct linear relationship between lower limb explosive strength and agility speed, indicating that an increase in one variable corresponds to an increase in the other. Increasing lower limb strength leads to increased agility.

The correlation further supports a strong positive relationship between the strength–agility (0.56342) and strength–agility speed (0.4364) variables, indicating their interdependence and mutual increase. Lower limb explosive strength influences agility speed, with an increase in lower limb strength resulting in increased agility. It remains to be explored why girls are more agile than boys despite having lower lower limb strength.

Conflicts of interest - The authors have no conflicts of interest to declare

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