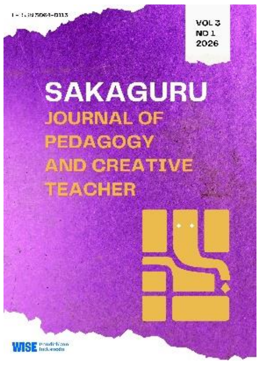


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Research Article

# Lower-Limb Power and 40-Meter Sprint Performance in Elementary Physical Education

Moh Chandra Mukti*, Fauzan Effendy, and Dicky Oktora Mudzakir

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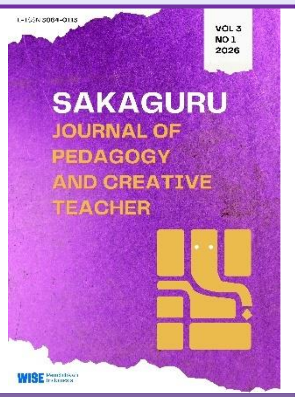
**Abstract**

Sprint performance in elementary physical education is a fundamental motor skill that requires lower-limb force production, coordination, acceleration ability, and efficient movement technique. This study aimed to examine the relationship between leg muscle power and 40-meter sprint performance among Grade V elementary school students. A quantitative correlational design was employed involving 17 students from UPTD SDN 1 Singakerta, Krangkeng District, Indramayu Regency, Indonesia. Leg muscle power was measured using a vertical jump test, while sprint performance was assessed through a 40-meter sprint test recorded in seconds. The data were analyzed using descriptive statistics and simple linear regression at a significance level of .05. The results showed that students obtained a mean vertical jump score of 78.53 cm (SD = 7.80) and a mean 40-meter sprint time of 14.24 seconds (SD = 2.31). The regression analysis revealed a statistically significant relationship between vertical jump performance and 40-meter sprint time, $F(1,15) = 6.740$, $p = 0.020$, with a moderate correlation coefficient ($R = 0.557$) and an explained variance of 31.0% ($R^2 = 0.310$). Since sprint performance was measured as completion time, the finding indicates that students with higher leg muscle power tended to complete the 40-meter sprint in a shorter time. This study concludes that leg muscle power is a meaningful physical component of short-distance running performance among elementary school students, although sprint ability remains influenced by other factors such as technique, coordination, maturation, and motivation. The implication is that physical education teachers should integrate safe, progressive, and age-appropriate lower-limb power activities with sprint technique instruction to support evidence-informed motor development in elementary physical education.

**Keywords:** 40-Meter Sprint; Elementary School Students; Leg Muscle Power; Physical Education; Vertical Jump






## INTRODUCTION

Sprint running is a fundamental locomotor task in elementary physical education because it integrates acceleration, lower-limb force production, postural control, arm–leg coordination, stride regulation, and movement confidence within a relatively simple but developmentally meaningful activity. In school-based physical education, sprinting should not be viewed merely as a competitive athletic skill, but as part of children's broader motor competence development, in which running, jumping, balancing, and other fundamental movement skills support physical activity participation, physical fitness, and psychosocial engagement [1], [2], [3]. Previous studies have shown that motor competence is associated with physical activity, muscular fitness, perceived competence, and motivation, indicating that children who develop better movement skills are more likely to participate actively and confidently in physical activities [4], [5], [6]. Therefore, examining physical factors related to sprint performance in elementary students is pedagogically important because it can help teachers design physical education activities that are developmentally appropriate, evidence-informed, and responsive to students' motor abilities.

From a biomechanical perspective, sprint performance is highly dependent on the ability to generate propulsive force rapidly against the ground, especially during the acceleration phase. Short-distance running requires coordinated extension of the hip, knee, and ankle joints, efficient use of the stretch–shortening cycle, appropriate body lean, and rapid transition between braking and propulsion. In children, sprinting ability is also shaped by growth and maturation, neuromuscular coordination, stride mechanics, and the progressive development of lower-limb strength and power [7], [8], [9]. Evidence from youth movement science indicates that jumping and sprinting share several neuromuscular characteristics, particularly the requirement to produce force quickly through the lower limbs [10], [11], [12]. This theoretical relationship explains why students with greater lower-limb explosive ability may be better able to push off the ground effectively and complete a short sprint in a shorter time.

Leg muscle power is commonly assessed through field-based jump tests because such tests are practical, inexpensive, and relatively easy to administer in school contexts. The vertical jump test is particularly useful because it reflects the ability of the lower limbs to produce explosive vertical propulsion, which is closely related to neuromuscular power and stretch–shortening cycle function [13], [14], [15]. Although vertical jumping and sprinting are not identical movement patterns, both require rapid force development, intermuscular coordination, and efficient lower-limb extension. Recent studies have reported meaningful associations between vertical jump performance and short-sprint ability in children and youth, suggesting that vertical jump tests can serve as useful indicators of lower-limb power and acceleration-related performance [11], [12], [16]. In this regard, vertical jump performance may provide physical education teachers with a simple diagnostic tool to identify students' lower-limb power capacity and to plan sprint-learning activities more appropriately.

Empirical evidence also shows that lower-limb power can be improved through structured neuromuscular and plyometric-oriented activities when these activities are designed according to age, maturation level, movement proficiency, and safety principles [17], [18], [19]. Meta-analytic findings indicate that plyometric and power-oriented training can improve jumping and sprinting outcomes in young populations, although the effects differ according to participant age, maturation status, sex, training frequency, program duration, and baseline physical condition [20], [21], [22]. However, these findings should be translated cautiously into elementary physical education because children are not miniature athletes. In the school context, power development should be embedded in playful, progressive, supervised, and technically simple movement tasks, such as jumping games, relay-based acceleration drills, low-intensity hopping, and sprint-technique activities. Thus, the educational goal is not early sport specialization, but the development of safe, enjoyable, and holistic movement competence.

Despite the growing evidence on the relationship between jumping ability and sprint performance, several research gaps remain. First, many previous studies have focused on athletes, sport-club participants, adolescents, or highly trained youth, while fewer studies have examined this relationship in ordinary elementary school physical education settings. Second, existing studies often use advanced laboratory equipment or sport-performance testing systems, whereas schools frequently require low-cost and field-based assessment methods that can be implemented by physical education teachers. Third, the Indonesian elementary school context remains underrepresented in the literature, particularly studies that examine how simple measures of leg muscle power are associated with sprint performance among primary-school students. These gaps are important because children's sprint performance in school may be influenced not only by power but also by technique, coordination, motivation, body size, learning experience, and maturation-related differences. Therefore, this study aims to examine the relationship between leg muscle power, measured using the vertical jump test, and 40-meter sprint performance, measured as sprint time in seconds, among Grade V elementary school students. The study is expected to contribute school-based empirical evidence on the role of lower-limb power in short-distance running and to provide practical implications for evidence-informed sprint learning in elementary physical education.

## METHODS

This study employed a quantitative correlational design to examine the relationship between leg muscle power and 40-meter sprint performance among Grade V elementary school students. This design was selected because the study did not involve treatment manipulation, random assignment, or experimental intervention, but aimed to determine whether naturally occurring variation in lower-limb explosive ability was statistically associated with sprint completion time in an authentic school-based physical education context [23], [24], [25]. The use of a correlational approach is appropriate for identifying the direction and magnitude of association between physical-performance variables, although the findings must be interpreted as associative rather than causal. In line with contemporary recommendations in sport and exercise science, the study emphasized clear reporting of participants, measurement procedures, descriptive statistics, regression indicators, and practical interpretation so that the results could be evaluated transparently and replicated in similar educational contexts [26], [27], [28].

The research was conducted at UPTD SDN 1 Singakerta, Krangkeng District, Indramayu Regency, Indonesia, during the school physical education period from 26 November to 6 December 2025. The participants were 17 Grade V students consisting of 10 boys and 7 girls. Because the target class was small and all eligible students participated, the study used an intact-class sampling approach. This sampling strategy was considered suitable for a school-based study because it allowed the researcher to examine physical-performance characteristics within a real physical education setting. However, the small and localized sample size limits the generalizability of the findings and requires cautious interpretation. Before data collection, the testing procedures were explained to the students using age-appropriate instructions, and the tests were conducted under teacher supervision to ensure safety, consistency, and student understanding. Because the participants were children, the final journal manuscript should explicitly report school permission, parental or guardian consent, student assent, confidentiality protection, and ethical approval according to the requirements of the target journal and the authors' institution.

Leg muscle power was measured using a vertical jump test. The vertical jump test was selected because it is a practical, low-cost, and field-based measure of lower-limb explosive ability that can be implemented in school physical education settings without advanced laboratory equipment. Previous studies have shown that vertical jump performance is useful for assessing lower-limb power and is meaningfully related to acceleration and short-sprint performance in children and youth populations [12], [29], [30]. In this study, each student stood beside a scaled measuring board, marked the standing reach height, and then performed a maximal vertical jump to touch the highest possible point. The score was recorded in centimeters, with a higher score indicating greater lower-limb explosive power. Prior to the test, students received a brief demonstration and were instructed to jump vertically with maximal effort while maintaining safe movement execution.

Sprint performance was measured using a 40-meter sprint test. Students started from the starting line and ran as fast as possible to the finish line, while the completion time was recorded in seconds. Because sprint performance in this study was operationalized as time, a lower value indicated better sprint performance. The 40-meter sprint distance was considered appropriate for elementary physical education because it reflects short-distance running ability and acceleration-related performance while remaining feasible within the school environment. Previous research indicates that sprinting performance in children is associated with lower-limb force production, coordination, maturation, and countermovement jump capacity, supporting the relevance of examining sprint time together with vertical jump performance [10], [11], [12]. To reduce measurement error, the same test area, starting procedure, timing method, and instruction pattern were maintained for all participants. Although stopwatch timing is practical in schools, the limitation of manual timing should be acknowledged because it may be less precise than electronic timing systems.

The data were analyzed using descriptive statistics and simple linear regression. Descriptive statistics were used to summarize the mean, standard deviation, and variance of vertical jump scores and 40-meter sprint times. Simple linear regression was then conducted to determine whether leg muscle power, represented by the vertical jump score, significantly predicted 40-meter sprint time. The vertical jump score was entered as the predictor variable, while sprint time was entered as the outcome variable. Statistical significance was evaluated at an alpha level of .05. The correlation coefficient (R) was used to describe the strength of association, while the coefficient of determination ($R^2$) was used to estimate the proportion of variance in sprint time explained by leg muscle power. Following recent recommendations in sport and exercise research, the interpretation of the findings considered not only the p-value but also the magnitude and practical meaning of the association, particularly because the sample size was small. Assumption checking should include linearity, residual normality, homoscedasticity, and the absence of influential outliers. Because the outcome variable was measured in seconds, a negative regression direction would indicate that students with higher vertical jump scores tended to complete the 40-meter sprint in a shorter time.

## RESULT AND DISCUSSIONS

### *Result*

#### *Descriptive Profile of Leg Muscle Power and 40-Meter Sprint Performance*

The descriptive analysis was conducted to provide an initial overview of students' leg muscle power and 40-meter sprint performance. As presented in Table 1, the mean vertical jump score was 78.53 cm with a standard deviation of 7.80, indicating that the students showed moderate variation in lower-limb explosive ability. Meanwhile, the mean 40-meter sprint time was 14.24 seconds with a standard deviation of 2.31, suggesting variability in students' ability to complete the short-distance sprint task. Since sprint performance was measured in seconds, a lower score indicates better performance. These descriptive findings show that students differed not only in their ability to generate vertical propulsion but also in their ability to translate lower-limb force production into sprint performance.

**Table 1**. Descriptive statistics of vertical jump and 40-meter sprint performance

| Variable | N | Mean | SD | Variance | Measurement unit | Interpretation |
|---|---|---|---|---|---|---|
| Vertical jump score | 17 | 78.53 | 7.80 | 60.77 | cm | Higher score indicates greater leg muscle power |
| 40-meter sprint time | 17 | 14.24 | 2.31 | 5.32 | seconds | Lower time indicates better sprint performance |

The descriptive results indicate that vertical jump scores were more dispersed than sprint times when viewed from their raw units, as reflected in the larger variance value for the vertical jump variable. However, the two variables represent different measurement scales; therefore, the descriptive values should not be compared directly as indicators of performance superiority. Instead, the vertical jump score should be interpreted as an indicator of explosive lower-limb power, while sprint time should be interpreted as the time required to complete a 40-meter sprint.

### *Regression Model Between Leg Muscle Power and Sprint Time*

Simple linear regression was used to examine whether leg muscle power, represented by the vertical jump score, was significantly associated with 40-meter sprint performance. The regression model showed a statistically significant relationship between vertical jump performance and sprint time, $F(1,15) = 6.740$, $p = 0.020$. As shown in Table 2, the model produced a correlation coefficient of $R = 0.557$, indicating a moderate association between the predictor and outcome variables. The coefficient of determination was $R^2 = 0.310$, meaning that approximately 31.0% of the variance in 40-meter sprint time was explained by vertical jump performance. The adjusted $R^2$ value of 0.264 suggests that, after adjustment for sample size and predictor number, the model still explained 26.4% of the variance in sprint time.

**Table 2**. Summary of the simple linear regression model

| Model indicator | Value | Statistical interpretation |
|---|---|---|
| R | 0.557 | Moderate association between vertical jump and sprint time |
| $R^2$ | 0.310 | Vertical jump explained 31.0% of the variance in sprint time |
| Adjusted $R^2$ | 0.264 | Adjusted explanatory power of the regression model |
| F(1,15) | 6.740 | Overall regression model statistic |
| p-value | 0.020 | Statistically significant at $\alpha = 0.05$ |
| Standard error of estimate | 1.98 | Average prediction error in seconds |

The regression result indicates that leg muscle power contributed meaningfully to sprint performance among the participating elementary school students. Because the outcome variable was measured as completion time, the association should be interpreted carefully. A better sprint performance is represented by a shorter completion time; therefore, the relationship suggests that students with higher vertical jump scores tended to complete the 40-meter sprint in less time. This result supports the assumption that lower-limb explosive ability is an important physical component in short-distance running, particularly in activities requiring rapid propulsion and acceleration.

### *Proportion of Explained Variance in Sprint Performance*

The coefficient of determination provides a clearer picture of the practical contribution of leg muscle power to sprint performance. As illustrated in Figure 1, vertical jump performance explained 31.0% of the variance in 40-meter sprint time, while the remaining 69.0% was not explained by the model. This remaining proportion may be associated with other factors not measured in this study, such as sprint technique, stride frequency, stride length, coordination, reaction to the start signal, body composition, motivation, maturation, and environmental conditions. Therefore, although leg muscle power was statistically significant, sprint performance among elementary school students should be understood as a multidimensional outcome.

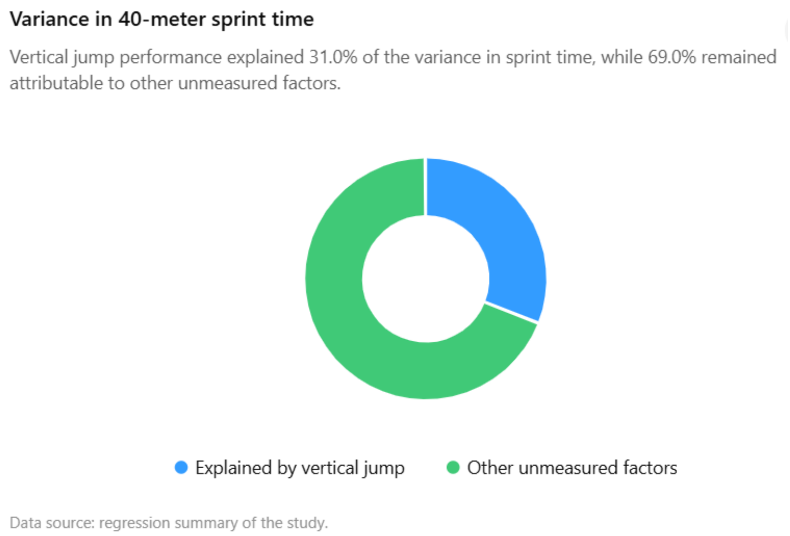



**Figure 1**. Proportion of variance in 40-meter sprint time explained by vertical jump performance.

### *Summary of Main Findings*

Overall, the results demonstrate that leg muscle power was significantly related to 40-meter sprint performance among Grade V elementary school students. The moderate correlation coefficient and statistically significant regression model indicate that vertical jump performance has a meaningful association with sprint time. However, the $R^2$ value also shows that leg muscle power is not the only determinant of sprint performance. These findings suggest that physical education teachers should consider lower-limb power as one important component of sprint learning while also addressing movement technique, coordination, motivation, and age-appropriate motor development.

### *Discussions*

The findings of this study indicate that leg muscle power, measured through the vertical jump test, was significantly associated with 40-meter sprint performance among Grade V elementary school students. The regression model showed a moderate relationship between vertical jump performance and sprint time, with vertical jump explaining 31.0% of the variance in 40-meter sprint performance. This result suggests that lower-limb explosive ability is an important physical component in short-distance running among children. Since sprint performance was operationalized as time in seconds, the association should be interpreted in an inverse direction: students with higher vertical jump scores tended to complete the 40-meter sprint in a shorter time. This finding supports the biomechanical assumption that students who can generate greater lower-limb propulsion may have a better capacity to produce effective push-off actions during the acceleration phase of sprinting.

The result is consistent with Chanel et al. [12], who reported that vertical jump performance was meaningfully related to acceleration capacity in prepubertal children. Their study emphasized that vertical jump tests can be useful indicators of lower-limb power when assessing children's short-distance running ability. The present study extends this evidence into an Indonesian elementary physical education context by showing that a similar association can be observed using simple school-based field tests. This alignment strengthens the argument that vertical jump assessment may be useful not only in sport-science laboratories or youth sport settings, but also in ordinary school environments where teachers need practical and low-cost assessment tools.

The present finding also corresponds with Wdowski et al. [11], who showed that sprinting and countermovement jump performance in boys are shaped by developing kinematic and kinetic capacities. Their findings suggest that children's sprint performance is influenced by the progressive development of force production, coordination, and movement mechanics. In relation to the present study, the moderate correlation between vertical jump and sprint time indicates that explosive leg power contributes to sprint performance but does not fully determine it. This is important because sprinting in children is a multidimensional motor task that requires not only muscular power but also stride regulation, postural control, arm swing coordination, and efficient transition between braking and propulsion.

This study is also supported by Radnor et al. [10], who explained that growth and maturation influence stretch–shortening cycle function in youth, which is relevant to both jumping and sprinting activities. Children's ability to jump higher and sprint faster may develop alongside neuromuscular maturation, tendon stiffness, muscle architecture, and improved motor-unit recruitment. The present study did not directly measure maturation status, but the unexplained variance of 69.0% indicates that developmental factors may have contributed to differences in sprint performance. Therefore, the findings should not be interpreted as evidence that sprint performance is determined solely by leg muscle power. Instead, lower-limb power should be understood as one component within a broader developmental system involving biological, technical, and motivational factors.

The findings are further supported by intervention studies and meta-analytic evidence on plyometric and neuromuscular training. Asadi et al. [20] found that plyometric training improved jumping ability and sprint performance in youth soccer players, with adaptations influenced by maturation. Similarly, Chen et al. [21] reported that plyometric training significantly enhanced lower-limb explosive strength in adolescent athletes, while Zheng et al. [22] concluded that plyometric training improved jumping, sprinting, and change-of-direction performance in adolescent soccer players. Although these studies were conducted mostly in athletic or adolescent populations, they provide relevant evidence that lower-limb power and sprint ability are closely connected. However, the present study differs from those intervention-based studies because it examined an intact elementary school class without applying a training program. Thus, the findings should be interpreted as correlational evidence rather than proof that increasing vertical jump performance will automatically cause faster sprint times.

A more cautious interpretation is also necessary when comparing the present results with Silva et al. [31], who emphasized that the effects of plyometric jump training on sprinting adaptations may vary according to maturation stage. This suggests that the relationship between leg power and sprint performance may not be uniform across all children. Some students may demonstrate good vertical jump performance but still record slower sprint times because of inefficient start technique, poor stride rhythm, limited coordination, or low motivation during testing. Conversely, students with moderate jumping ability may perform relatively well in sprinting if they have better coordination and running mechanics. Therefore, the moderate R value in this study is theoretically reasonable because sprint performance is influenced by multiple interacting factors rather than by one physical component alone.

The novelty of this study lies in its school-based contribution to the literature on children's sprint performance. Previous studies have frequently focused on athletes, youth sport participants, adolescents, or laboratory-based measurements, whereas this study examined Grade V elementary school students in an authentic physical education setting using simple field-based tests. This context is important because physical education teachers often work with limited equipment and require practical assessment methods that can be implemented safely and efficiently. By demonstrating that vertical jump performance explains a meaningful proportion of 40-meter sprint performance, this study provides empirical support for using lower-limb power assessment as part of evidence-informed sprint learning in elementary schools.

The practical implication of this study is that physical education teachers should consider lower-limb power as one important component in designing sprint-learning activities. Activities such as standing jumps, low-intensity hopping games, relay-based acceleration tasks, short sprint drills, and movement games that emphasize safe push-off mechanics may help students develop the physical qualities needed for short-distance running. However, these activities should be implemented progressively and playfully, with attention to safety, enjoyment, and individual differences. Teachers should not reduce sprint learning to power development alone, because the results show that most of the variance in sprint time was explained by other factors. Therefore, sprint instruction should also include start technique, arm swing coordination, body posture, stride rhythm, motivation, and confidence-building feedback.

This study also has implications for school-based assessment. The vertical jump test can be used as a practical screening tool to help teachers identify students' lower-limb explosive ability and design more responsive learning activities. However, assessment results should not be used to label students as talented or untalented. Instead, the results should guide differentiated physical education instruction by helping teachers understand students' physical readiness and movement needs. At the policy level, the findings support the importance of providing adequate open space, simple measurement tools, and teacher training in physical fitness assessment so that physical education can be conducted more systematically and evidence-based.

Several limitations should be acknowledged. First, the study involved only 17 students from one elementary school, so the findings cannot be generalized broadly to all elementary school students. Second, sprint performance was measured using a stopwatch, which is practical for school settings but less precise than electronic timing systems. Third, the study did not include anthropometric variables, maturation status, body mass index, sprint-technique assessment, physical activity history, or motivational factors, all of which may influence sprint performance. Fourth, the study used a correlational design; therefore, it cannot establish a causal relationship between leg muscle power and sprint performance. Future research should involve larger and more diverse samples, compare boys and girls separately where possible, use more precise timing instruments, include developmental and biomechanical variables, and examine whether structured age-appropriate lower-limb power activities can improve sprint performance in elementary physical education.

## CONCLUSION

This study concludes that leg muscle power, measured through the vertical jump test, has a significant association with 40-meter sprint performance among Grade V elementary school students. The regression results indicate a moderate relationship between vertical jump performance and sprint time, with leg muscle power explaining 31.0% of the variance in 40-meter sprint performance. Since sprint performance was operationalized as completion time, the finding suggests that students with higher lower-limb explosive ability tended to complete the sprint in a shorter time. These results confirm that leg muscle power is an important physical component in short-distance running; however, it should not be regarded as the sole determinant of sprint performance. Sprint ability in children remains a multidimensional outcome influenced by technique, coordination, maturation, motivation, body characteristics, and learning experience. The study contributes to school-based physical education by demonstrating that the vertical jump test can serve as a practical and low-cost assessment tool for identifying lower-limb power related to sprint performance. Practically, physical education teachers are encouraged to integrate safe, progressive, enjoyable, and age-appropriate lower-limb power activities with sprint technique instruction to support students' motor development. Nevertheless, the findings should be interpreted cautiously because the study involved a small intact-class sample from one elementary school and used stopwatch-based sprint measurement. Future research should involve larger and more diverse samples, apply more precise timing systems, include developmental and biomechanical variables, and examine whether structured lower-limb power interventions can improve sprint performance in elementary physical education settings.

## LIMITATIONS

This study provides school-based empirical evidence that leg muscle power, as measured through the vertical jump test, is meaningfully associated with 40-meter sprint performance among elementary school students. The findings address the research objective by showing that lower-limb explosive ability contributes to short-distance running performance in a real physical education context. This result helps fill the gap in previous studies that have more frequently examined sprint and jump relationships in athletic, adolescent, or laboratory-based populations rather than in ordinary elementary school settings. However, several limitations should be acknowledged. First, the study involved a small intact-class sample from a single elementary school, which limits the generalizability of the findings to broader student populations. Second, sprint performance was measured using a stopwatch, which is practical for school-based assessment but less precise than electronic timing systems. Third, the study did not include other potentially influential variables, such as body composition, maturation status, sprint technique, stride mechanics, motivation, physical activity history, and environmental conditions. Fourth, the correlational design only identifies statistical association and cannot establish a causal relationship between leg muscle power and sprint performance. Despite these limitations, the study has practical implications for elementary physical education. Teachers may use the vertical jump test as a simple, low-cost screening tool to understand students' lower-limb power and design more responsive sprint-learning activities. Policy and practice in physical education should support safe, progressive, and age-appropriate power-oriented activities, while also integrating sprint technique, coordination, confidence-building, and enjoyable movement experiences. Future studies should involve larger and more diverse samples, apply more precise measurement tools, and examine whether structured lower-limb power interventions can improve sprint performance in elementary school students.

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## AUTHOR CONTRIBUTION

CM contributed to the conceptualization of the study, data collection, field testing, data organization, formal analysis, and preparation of the initial manuscript draft. FE contributed to methodological refinement, supervision, validation of the research process, interpretation of findings, and critical revision of the manuscript. DM contributed to academic supervision, review of the theoretical framework, verification of the discussion, and manuscript editing. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

The authors acknowledge the use of AI-assisted writing tools to support language refinement, academic phrasing, structural organization, and clarity of expression during manuscript preparation. The AI tool was not used to generate or modify raw data, conduct independent statistical analysis, fabricate references, or determine the scientific conclusions of the study. All AI-assisted outputs were critically reviewed, verified, and revised by the authors to ensure accuracy, originality, methodological consistency, and compliance with academic integrity standards. The authors take full responsibility for the final content, interpretation of findings, citation accuracy, and scholarly validity of the manuscript.

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