



Associations between physical activity intensity and motor balance in elementary school students: A sequential explanatory mixed-methods study

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- A – Research concept and design
- B – Collection and/or assembly of data
- C – Data analysis and interpretation
- D – Writing the article
- E – Critical revision of the article
- F – Final approval of article



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ABSTRACT

Background: Children in primary school are becoming more sedentary due to advances in digital technology, which may reduce their physical activity levels. The development of motor skills, especially balance, which is an essential feature of children's motor abilities, can be impacted by a lack of physical activity.

Objective: This study aimed to examine the association between physical activity intensity and motor balance in elementary school students.

Methods: This study used a sequential explanatory mixed-methods design. The quantitative phase involved 50 students selected using saturated sampling, while the qualitative phase involved teachers and students selected purposively. Physical activity intensity was measured using the Physical Activity Questionnaire for Older Children (PAQ-C), while motor balance was assessed using the Balance Beam Test. Quantitative data were analyzed using Spearman's rank correlation, and qualitative data were analyzed using thematic analysis in NVivo.

Results: With a correlation coefficient of $r = 0.687$ and $p < 0.05$, the analysis demonstrated a strong, substantial positive link between motor balance levels and physical activity intensity. The intensity of physical activity accounted for 47.2% of motor balance. Qualitative research revealed that students with high levels of physical activity were more likely to engage in active play, such as running outside, cycling, and football, which, in turn, indirectly improves balance and postural stability.

Conclusion: This study demonstrates that physical activity intensity plays an important role in the development of motor balance among elementary school students. These findings highlight the importance of integrating active movement-based learning strategies in physical education programs.

Keywords: elementary school students, motor balance, physical activity.

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INTRODUCTION

Students' physical activity habits have been greatly affected by the rapid growth of digital technology, which often promotes sedentary lifestyles that may impede the development of basic motor skills (Agafonov et al., 2021; Papale et al., 2025). Numerous studies have demonstrated that children who engage in little physical exercise experience a deterioration in motor abilities, particularly balance, which is essential for the development of more complex motor skills (Felix et al., 2020; Ostrowska et al., 2020).

Children's physical activity is greatly enhanced by motor balance, both in everyday activities and in physical education. Children's ability to maintain body stability while standing and moving directly affects how well they walk, run, jump, and change direction (Moon & Jung, 2021). Children with poor balance are indeed more likely to struggle with motor tasks and school-based physical activities. The ability to execute a variety of actions, from simple to intricate motor tasks, is based on the fundamental motor skill of balance (Yanovich & Bar-Shalom, 2022).

The intensity of physical activity is considered one of the key factors influencing the development of motor balance. Regular and sufficiently intense physical activity can stimulate the neuromuscular system, improve coordination, and strengthen postural control mechanisms (Krivolapchuk et al., 2022). Previous studies have also reported that elementary school students with higher levels of physical activity tend to exhibit better motor performance than those with lower levels (Dao, 2025). These findings suggest that physical activity is not only a recreational activity but also an important component supporting children's motor development.

Despite these findings, previous studies have widely examined the relationship between physical activity and motor development in children. Research by Dana et al. (2023) shows that moderate-to-vigorous physical activity (MVPA) is positively associated with children's motor proficiency, particularly gross motor skills. However, a significant research gap remains. Most studies rely on quantitative approaches that focus on statistical relationships, providing limited insight into contextual factors such as students' daily habits, learning environments, and physical education practices. In addition, prior research tends to examine motor skills in general rather than focusing specifically on motor balance. There is also a limited understanding of how different levels of physical activity intensity influence balance.

This issue is also reflected in physical education practices in elementary schools, where learning often focuses on technical skill mastery rather than achieving optimal physical activity intensity. As a result, the potential impact of activity intensity on motor balance is not fully optimized. Good motor balance not only supports movement performance but also contributes to posture control, injury prevention, and readiness for more complex physical activities (Ferriyani et al., 2021; Markowicz et al., 2023).

Therefore, this study aims to address these gaps by using a mixed-methods, sequential explanatory design to examine the relationship between physical activity intensity and motor balance among elementary school students.

METHODS

Study Design and Participants

This study employed a mixed-methods approach using a sequential explanatory design, in which quantitative data were collected and analyzed in the first phase, followed by qualitative data collection to explain and enrich the quantitative findings. The quantitative phase examined the relationship between physical activity intensity and motor balance, while the qualitative phase explored students' experiences, habits, and contextual factors that influence their physical activity. The integration of both data sets was conducted at the interpretation stage to provide a more comprehensive understanding of the research problem.

Participants in this study were IV, V, and VI-grade elementary school students at Rancamedalwangi Elementary School, located in Sumedang Regency, West Java, Indonesia. A total of 50 students participated in the quantitative phase, and all participants were included in the data analysis (total sampling). Quantitative data were collected through a physical activity questionnaire and a motor balance test.

For the qualitative phase, five participants were selected using purposive sampling based on the quantitative results to obtain more in-depth information. These participants included two students, one physical education (PJOK) teacher, and two classroom teachers to capture diverse perspectives on students' physical activity and motor balance.

Ethical approval statement

Given that the subjects were students at Rancamedalwangi Elementary School, the researcher obtained official permission from the Indonesian University of Education, Sumedang Campus, through letter number B-143/UN40.C2.1/PT.01.01/2026. This research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The researcher provided the school and the children who comprised the population with a thorough explanation of the study's methods and goals prior to data collection.

Research Instruments

Physical activity intensity was measured using the Physical Activity Questionnaire for Older Children (PAQ-C), which assesses children's physical activity levels over the previous seven days using a 5-point Likert scale. The Indonesian version of the instrument has been validated, showing factor loadings above 0.5, an Average Variance Extracted (AVE) of 0.659, and a Composite Reliability (CR) of 0.892, indicating good validity and reliability. Motor balance was evaluated using the Beam Balance Test, which measures students' ability to maintain dynamic balance while walking along a 3-meter line simulating a balance beam. The number of successful steps is recorded as a performance score, with reliability reported in the range of $r = 0.60$ – 0.80 . Qualitative data were collected through semi-structured interviews to explore students' activity habits, motivation, and environmental factors influencing their physical activity and balance.

Research Procedure

The study was carried out in phases. The school's consent was first sought, demonstrating respect for institutional collaboration, and then the research schedule

was coordinated with the teachers to ensure smooth cooperation. Under the researcher's guidance, students completed the PAQ-C questionnaire and took the motor balance test during the quantitative phase. The association between the factors was then ascertained by analyzing the gathered data.

Participants for the qualitative stage were selected based on the quantitative findings to ensure relevance and depth. To gain a deeper understanding of physical activity behaviors and contributing factors, semi-structured interviews were conducted with a subset of students and teachers. Ultimately, a thorough interpretation of the results was produced by integrating the quantitative and qualitative findings, highlighting the comprehensive nature of the study.

The overall research procedure is illustrated in [Figure 1](#), showing the sequential process from quantitative data collection and analysis to qualitative exploration and data integration.

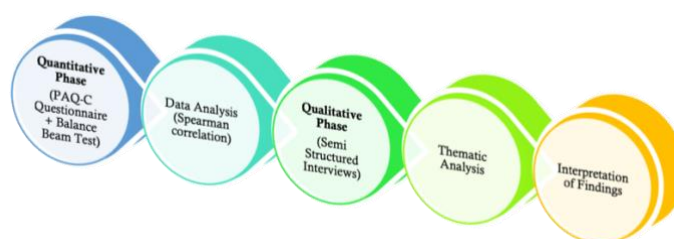


Figure 1. Sequential Explanatory Mixed-Methods Research Design

Data Analysis

Quantitative data were analyzed using Spearman's rank correlation because one variable failed the normality assumption, as assessed by the Kolmogorov-Smirnov test. The significance level was set at $p < 0.05$. The coefficient of determination (r^2) was also calculated to estimate the contribution of physical activity intensity to motor balance performance. Qualitative data from interviews were analyzed using thematic analysis, supported by NVivo 12.

RESULTS

The findings of this study are derived from data collected from 50 elementary school students. The presentation of results is organized into descriptive statistics, assumption testing, correlation analysis, and qualitative visualization.

As shown in [Table 1](#), physical activity scores exhibit a wider range than motor balance scores, indicating greater variability among students. In contrast, motor balance scores are more clustered, suggesting relatively consistent performance. The normality test results indicate that the physical activity data meet the normality assumption, whereas the motor balance data do not. This indicates that the distribution of motor balance scores deviates from normality, justifying the use of non-parametric statistical analysis for subsequent testing.

According to [Table 2](#), the Spearman Rank correlation analysis of 50 students ($N=50$) yielded a correlation coefficient (r) of 0.687. This value indicates a positive relationship: the higher the intensity of physical activity, the better students' motor balance. Based on the criteria for interpreting correlation coefficients, the value of $r = 0.687$ indicates a strong relationship. The results of the significance test showed Sig. 0.000, which is smaller than the significance level of $\alpha = 0.05$ ($0.000 < 0.05$).

Thus, there is a significant relationship between the intensity of physical activity and students' motor balance.

Table 1. Descriptive Statistics of Physical Activity and Motor Balance Levels

Variable	Minimum	Maximum	Mean	Std. Deviation	Kolmogorov–Smirnov
Physical Activity	16	44	28.36	7.37	0.106
Motor Balance	1.6	5	3.45	0.91	0.148

Table 2. Results of the Correlation Test of Physical Activity Intensity and Motor Balance Levels

Classification	N	Koef. Correlation (r)	Sig.	Correlation
Associations Between Physical Activity Intensity and Motor Balance in Elementary School Students	50	0.687	0.000	Significance

The coefficient of determination (R^2) = $r^2 \times 100\%$ is used to quantify the contribution of physical activity intensity to motor balance. $R^2 = (0.687)^2 \times 100\% = 0.472 \times 100\% = 47.2\%$, according to the computation. This finding indicates that although physical activity intensity contributes to motor balance, it is not the only determining factor. In practical terms, increasing students' physical activity can improve balance performance, but other factors, such as the environment, learning methods, and individual characteristics, also play important roles.

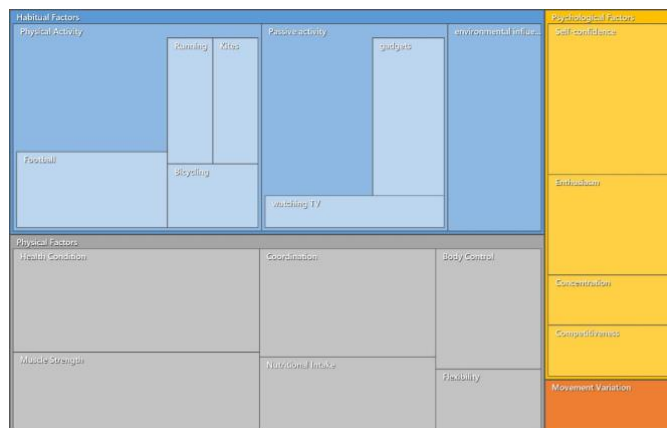


Figure 2. Visualization of Interview Analysis Results Themes Using NVivo 12

Figure 2 shows that habitual variables are the most prevalent theme, especially in physical exercise. Running, cycling, kite flying, and football are common subthemes. This suggests that adolescents who participate in high levels of physical activity are more likely to be used to active outdoor activities. On the other hand, the subthemes of using gadgets and watching television also became prominent in the passive activity category, especially among students who did not engage in much physical exercise. These results show variations in daily routines that affect students' levels of physical exercise.

Physical characteristics were another important issue in the interviews, along with behaviors. Health, muscle strength, coordination, body control, flexibility, and nutritional intake were among the many topics discussed. Students with high muscle strength and coordination tended to be steadier during balance tests, according to

teacher informants. This implies that motor balance is linked to other physical elements rather than existing in a vacuum.

The next theme is psychological aspects, such as self-assurance, zeal, focus, and competitiveness. In physical education classes and games, students who engage in a lot of physical activity typically exhibit greater self-assurance and excitement. On the other hand, students who do not engage in much physical activity often lack confidence and concentration when executing balance-related tasks.

DISCUSSION

The study's findings demonstrated a strong, significant correlation between elementary school students' motor balance and their level of physical activity ($r = 0.687$, $p < 0.05$). This suggests that their motor balance skills improve as physical activity intensity increases. Put another way, students' capacity to maintain body stability during a variety of movements is positively impacted by more frequent and intense physical activity.

The relatively strong correlation indicates that physical activity level is an important factor in the development of motor skills. However, the coefficient of determination of 47.2% indicates that the relationship in question does not fully explain the variation in students' motor skills. Thus, there are still several other factors that could be detrimental, such as environmental conditions, daily activities, and the quality of education that students receive. These findings support the idea that physical activity serves as both a leisure activity and a crucial part of the development of students' fundamental motor skills, particularly in maintaining bodily stability and control when moving.

Practically speaking, these findings support the idea that exercise is more than just a recreational activity; rather, it is an essential part of the development of fundamental motor abilities, especially those related to maintaining bodily stability and control during movement. These results are consistent with earlier research demonstrating a favorable correlation between physical activity and kids' motor development, especially in balance and coordination. It has been noted that children who engage in more physical activity have greater motor control than those who do not (Li et al., 2022; Nilsen et al., 2020; Skaltsa et al., 2021). Additionally, it has been demonstrated that basic motor abilities are greatly enhanced by moderate-to-vigorous physical activity (MVPA). In contrast to the results of several earlier investigations, our research supports this notion and offers fresh perspectives on the robust association between these two variables, indicating that physical activity intensity is a dominant influence (Balaban, 2018; Wang et al., 2022).

The mechanisms of the neuromuscular system, sensorimotor control, and postural regulation provide a physiological explanation for the link between physical activity intensity and motor balance. Frequent exercise, especially at moderate to high intensities, can improve muscle activation and promote integration between the central and peripheral neural systems. Better motor coordination, postural stability, and a more adaptable body response to positional changes and balance disruptions are all facilitated by this process (Iqbal, 2011; Rogge et al., 2018; Zemková, 2022). Additionally, exercise is essential for optimizing the performance of sensory systems, including the vestibular system, which controls the body's orientation to gravity, and

proprioception, which helps the body determine the position of its limbs. The body's capacity to maintain stability while moving will be gradually developed through repetitive stimulation of dynamic motions such as sprinting, jumping, and changing direction. This will ultimately improve postural control and the capacity to quickly change balance in a variety of scenarios (Simões et al., 2026; Promsri et al., 2020).

Qualitative data demonstrating that students who participated in more strenuous physical activities, like outdoor play, tended to have better balance skills corroborated the study's quantitative findings. On the other hand, less active students, especially those who engaged in more sedentary activities, showed comparatively poor motor control (DuBose et al., 2018; Haugland et al., 2026). The integration of these findings demonstrates consistency between quantitative and qualitative data, thereby strengthening the research's validity. However, these qualitative findings also indicate variations in student behavior that the quantitative data cannot fully explain. This integration strengthens the explanatory power of the findings, as quantitative results are supported and enriched by qualitative insights.

The findings of this study highlight the importance of physical exercise intensity in promoting the motor development of elementary school students. As a result, mastering movement skills should not be the primary goal of Physical Education, Sports, and Health (PJOK) training; attaining appropriate physical activity intensity during the learning process should also be given top priority. To give the most stimulation for the nervous system and bodily coordination, physical education teachers must create games with explosive features and direction shifts to engage children actively. Additionally, schools are obliged to support students by offering suitable environmental facilities. Collaboration among stakeholders and support from the school environment are essential for the overall development of children's gross motor skills while also lowering sedentary behavior that may impede their development (Adi et al., 2022; Muhammad & Alexander, 2024).

Limitations of the study

This study has several limitations that should be considered when interpreting its findings, despite its significant contributions. The first drawback is that the results cannot be widely extrapolated to a broader population due to the small sample size, which only comprised one institution. Additionally, this study did not adequately account for variables that might affect the outcomes, such as specific environmental conditions, baseline fitness status, or variations in individual student characteristics. To get a more accurate picture of the dynamics of children's motor development, future studies should employ a larger, more varied sample and more objective, thorough measurement tools.

CONCLUSION

This study demonstrates a significant positive relationship between physical activity intensity and motor balance among elementary school students. The findings indicate that greater physical activity engagement is associated with better motor balance performance. However, this relationship does not imply causality, as various other factors may also influence motor development. This study provides empirical evidence that physical activity intensity plays an important role in supporting motor balance development in the context of elementary education. Practically, these

findings highlight the importance of integrating active movement-based strategies into physical education programs. Future research is recommended to involve larger samples and consider a broader range of variables, including environmental, behavioral, and individual factors.

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AI DISCLOSURE STATEMENT

During the preparation of this manuscript, the authors used DeepL Translate and Grammarly to assist in translation, check grammar, improve linguistic clarity, and refine the academic English phrasing of the text. All outputs generated with these tools were critically reviewed and thoroughly edited by the authors to ensure factual accuracy, clarity of expression, and compliance with academic standards. The authors take full responsibility for the integrity and content of this manuscript.

DATA AVAILABILITY

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

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CONFLICT OF INTEREST

The author declares no conflict of interest.

PUBLISHER'S NOTE

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