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Structural analysis of physical activity, self-efficacy on academic achievement, and critical thinking abilities of elementary school children

Análisis estructural de la actividad física, la autoeficacia en el rendimiento académico y las habilidades de pensamiento crítico de niños de escuela primaria

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Abstract. This research is intended to explore the impact of physical activity (PA) on Academic Grades (AG) and Critical Thinking (CT), along with the moderating role of Self-Efficacy (SE) in this relationship. Methods: Data collection was carried out through statistical analysis of test and survey results given to research participants. Results: The results of the analysis indicate that physical activity has a significant influence on AG and CT at the 95% confidence level, which is strengthened by the P value and t statistic which exceed the significance threshold. In addition, Self-Efficacy was also proven to have a significant role in linking physical activity with AG and CT. The implications of this research show the urgency of promoting physical activity as an element of improving academic performance and critical thinking abilities, with a special focus on strengthening self-efficacy. Conclusion: The conclusions of this research can be a guide for policymakers, educators and other stakeholders in designing comprehensive and sustainable education strategies.
Keywords: Physical activity, critical thingking, self-efficacy, academic grades, structural equation modelling.

Resumen. La educación básica es fundamental para el crecimiento de los niños, enfatizando el desarrollo de habilidades de pensamiento crítico (CT) para mejorar las calificaciones académicas (AG). La CT, crucial para analizar información y tomar decisiones efectivas, se alinea con los objetivos educativos contemporáneos. AG abarca habilidades cognitivas vitales para el aprendizaje y la adaptación. Los logros en inteligencia dan forma al éxito académico y en la vida en general. El desarrollo del CT de los niños está influenciado por los rasgos individuales y las Actividades Físicas (AF), esenciales para el crecimiento integral. Los estudios destacan la mejora de la TC por parte de la PA a través del aumento del flujo sanguíneo cerebral, lo que mejora la función cognitiva y la concentración. La PA aumenta indirectamente el AG al mejorar la salud mental y la concentración. Sin embargo, las actividades sedentarias predominantes en la provincia de Yakarta subrayan una falta de AF, lo que podría afectar tanto a la AP como a la AG. La educación primaria sienta las bases para la adquisición de conocimientos, y la CT da forma a la perspicacia intelectual. Lo socioemocional (SE) influye en el desarrollo de la CT, y una SE sólida fomenta la resiliencia y enriquece la CT. Equilibrar la AF es crucial, ya que la actividad moderada mejora la concentración y la salud mental, mientras que la actividad excesiva puede provocar fatiga y estrés, lo que afecta el aprendizaje. Metodológicamente, este estudio utiliza cuestionarios de escala Likert y modelos de ecuaciones estructurales (SEM) para explorar la dinámica de PA, SE, CT y AG entre niños de escuela primaria en Yogyakarta, Indonesia. Los resultados resaltan la influencia significativa de la PA en AG, CT y SE, y la SE modera los efectos de la PA sobre AG y CT. En conclusión, la AF desempeña un papel fundamental en la AG y la CT de los niños, ofreciendo información valiosa sobre su desarrollo integral. Este estudio proporciona un marco para optimizar los resultados del aprendizaje y fomentar el enriquecimiento cognitivo en los niños.

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Introduction

Basic education is a crucial foundation for the cognitive and emotional development of children. One important aspect of basic education is the development of critical thinking (CT) skills to enhance Academic Grades (AG). Building various thinking skills is currently considered a fundamental goal in the education system (Akbarilakeh et al., 2018). CT is an essential skill that needs to be developed in students at school because it enables them to analyze information deeply, evaluate different perspectives, and make decisions based on logical reasoning (Taningrum et al., 2024). CT enables children to analyze information, solve problems, and make decisions effectively. Meanwhile, AG refers to the general cognitive abilities that allow children to learn, understand, and adapt to their environment. Success in intelligence is the ability to achieve success in life, serving as the basis for guiding individual goals in their environmental context. Thus, successful intelligence is not only the foundation for academic achievement but also for overall life accomplishments (Sternberg, 2002). Other explanations also provide evidence that indicators of academic achievement, especially technology readiness and the psychological well-being of elite student athletes (Ridwan et al., 2023). The development of children's CT is undoubtedly intertwined with their individual characteristics as they strive to enhance AG. The role of a child's growth and development holds a unique place in cultivating the child's critical thinking abilities. Additionally, the PA that children engage in daily play a crucial role in the growth and development of children, and the relationship between PA, CT, and AG is not yet fully understood. PA plays a central role in the holistic growth and development of children. Engaging in regular physical activity is one key element that individuals can undertake to enhance well-being in terms of health (Olson et al., 2022; Piercy et al., 2018).

Several studies indicate that PA can enhance children's CT (Blegur et al., 2023; Christine Berg & Taff, 2023). PA can increase blood flow to the brain, a process that enhances cognitive function (Izatulislami & Noortje Anita

Kumaat, 2022; Ningrum et al., 2023). PA also has a positive impact on a child's concentration, making them more focused in learning to support success in AG. Another research suggests that PA can indirectly improve a child's AG. PA can help improve mental health, reduce stress in children, and contribute to better concentration in learning. Good PA can assist in reducing anxiety and depression, improving mood, and enhancing sleep quality. This aids children in learning more effectively and enhancing their CT (Bachtiar et al., 2023; Mahindru et al., 2023; Singh et al., 2023). Furthermore, PA can help children build confidence and self-esteem, which can boost their motivation to learn and improve their AG.

PA such as sports and games can enhance blood flow to the brain, bringing more oxygen and nutrients to the brain (Srimulyati et al., 2023), providing a stimulus for children to improve cognitive function, including CT. Well-oxygenated brains can process information faster and more efficiently, assisting children in learning and understanding materials better. PA also helps children to focus and concentrate (Fatchuroji et al., 2023; Sabaruddin, 2017). During PA, the body releases endorphins, hormones that can boost mood and reduce stress (Khandare, 2023; Rusdiana & Computer, 2023). This helps children to be more focused on learning tasks and enhances their ability to think critically. This is further clarified by scientific evidence indicating a positive relationship between physical activity (PA) habits and the quality of life experienced by adolescents and young individuals. The research shows that this variable is subjective and affects an individual's overall well-being (Garcia Canto, E. et al., 2021). Physical activity (PA), such as sports and games, enhances brain oxygenation, improving cognitive function and critical thinking, boosts mood through endorphin release, and positively impacts focus, concentration, and overall well-being in children and adolescents.

The portrayal of PA in Indonesia, specifically in Jakarta Province, reveals that measurements of PA levels in subjects indicate that 59.7% of subjects engage in light activities (Lontoh et al., 2020). This aligns with findings from research stating that the majority of Indonesian society spends most of their time in front of gadgets, television, and monitors (Andriyani et al., 2022). Hence, it can be said that the level of PA in the Indonesian population is still far from the standard. The above description is one form of assessment indicating that the level of PA in Indonesian children is still in the light category. This will have an impact on both PA and AG in children. The context of this research explores the connection between feelings, PA, and children's CT, ultimately contributing to better AG.

Education during the Elementary School age plays a crucial role in shaping the foundation of knowledge and skills for children. During this period, children undergo significant cognitive and social development, and the success of learning at this stage can form a strong basis for future academic success.Recognizing that physical education has been the subject of extensive scientific research across various topics, we now understand the cognitive, physical, and social benefits of regular physical activity (Folgado dos Santos et al., 2020). CT is a crucial element in shaping a child's intelligence (Dulun & Lane, 2023; Li, 2023; Pulatova, 2023). This involves the capacity to analyze information, understand arguments, and make decisions based on data. CT not only holds relevance in the academic domain but also plays a significant role in daily life and the process of structured cognitive development.

Education at elementary school age plays an important role in forming a foundation of knowledge and skills, especially in children's cognitive and social development, with success at this stage becoming the basis for future academic achievement (Dulun & Lane, 2023; Li, 2023; Pulatova, 2023). Sports activities in physical education also contribute to citizenship education, including through a critical pedagogy approach that strengthens digital and environmental awareness and the importance of critical thinking (CT) in shaping children's intelligence (Fuentes, M. et al., 2024).

The examination of the above variables plays a role in shaping a child's CT to be better. However, without the presence of SE in children, the development of their CT in asserting themselves in life may be hindered. SE, as an individual's belief in their ability to succeed in specific tasks, also holds great potential in shaping CT (Antonios Christodoulakis George Kritsotakis & Tsiligianni, 2023; Tasgin & Dilek, 2023). Children with high levels of SE are likely to face challenges with a positive attitude, enriching their CT (Hui Zhao Yan Li & Li, 2023; Papadakis et al., 2024). Based on this explanation, it is important to consider further research on SE as a mediator in the relationship between PA and the improvement of CT to enhance AG. Meanwhile, the influence of CT on AG also remains a significant focus. Children with CT are expected to analyze information more effectively, make informed decisions, and solve problems efficiently; these factors, overall, can have a positive impact on their academic achievements.

This explanation illustrates the importance of finding the right balance in physical activity (PA) to maximize its benefits for critical thinking (CT) and academic grades (AG). Moderate and regular PA can enhance blood flow to the brain, improve focus and concentration, boost mental health, and build confidence. CT can stimulate students' critical thinking abilities, so that contextual learning strategies can be applied to students (Thamrin, L et al., 2024). However, excessive or inappropriate PA, considering the child's age and abilities, can lead to fatigue, stress, injuries, and other health issues that may disrupt learning and diminish both CT and AG. Therefore, addressing these concerns requires a definitive answer to establish a balance among PA, self-efficacy (SE), CT, and AG. This research focuses on the primary investigation of a structural analysis model on PA with CT and AG in elementary school children.

Methods

This research falls within the category of quantitative research utilizing Likert-scale questionnaires. The study focuses

on analyzing physical activity, self-efficacy, critical thinking skills, and academic achievement among elementary school children in Yogyakarta, Indonesia. The research involves 814 participants selected through quota sampling techniques. The questionnaires were administered over a three-month period from October to December 2023 at elementary schools in the Yogyakarta Province, Indonesia. The research instruments used for data collection include the Physical Activity Questionnaire for Children (PAQ-C) for assessing PA (Voss et al., 2017), a Self-Efficacy Scale for SE (Novrianto et al., 2019), a Critical Thinking Skills Questionnaire for CT (Ardi et al., 2023), and Academic Achievement measured through report card grades (York et al., 2015). Data analysis employs Structural Equation Modeling (SEM) using the Smart PLS 4.0 application. Testing includes outer model testing, validity testing, reliability testing, and inner model testing.

Results

This study applies data analysis using the PLS-SEM method with the SmartPLS software. The data processing process consists of two stages, namely Outer Model Evaluation and Inner Model Evaluation. Details regarding the data processing at each stage can be found below.

Outer Model Testing

The Outer Model Evaluation is used to assess whether the research instruments meet the criteria for high-quality data, involving the validity and reliability of the data (Kelley et al., 2003). In the analysis of the outer model coefficients, it is evident that the concepts and research model cannot be tested in a predictive relational and causal model without passing the purification stage in the measurement model. The measurement model (outer model) is used to test the construct validity and instrument reliability. Further explanation regarding the testing of validity and reliability can be seen in the modeling below:

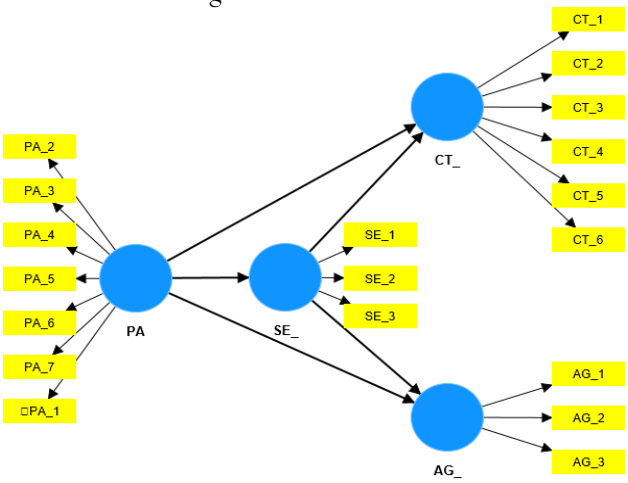

Figure 1. The Trend of Economic Development

Validity Testing

Validity testing is an assessment used to describe the extent to which an instrument is related or capable of measuring what it intends to measure. The success of the research is considered valid if there is consistency between the actual data that occurs in the research object and the collected data (Pandey & Pandey, 2021).

Convergent Validty

Convergent Validity is the measurement of the extent to which there is a correlation between indicators and variables. In this context, an indicator is considered valid as a measure of its variable if the loading factor has a value >0.6 (Baistaman et al., 2020). Validity testing is used to ensure respondents' understanding of the questionnaire statements. Another perspective suggests that sufficient validity has loading factor values between 0.50 - 0.60 and Average Variance Extracted (AVE) >0.50 (Wiyono, 2011). In this research, the researcher applies loading factor values ≥ 0.50 and AVE values ≥ 0.50, with Smart PLS 4.0 results indicating the loading factors as follows.

Table 1.
Convergent Validity Test Results

	AG_	CT_	PA	SE_
AG_1	0.710			
AG_2	0.827			
AG_3	0.849			
CT_1		0.765		
CT_2		0.844		
CT_3		0.877		
CT_4		0.880		
CT_5		0.876		
CT_6		0.827		
PA_2			0.562	
PA_3			0.598	
PA_4			0.713	
PA_5			0.788	
PA_6			0.834	
PA_7			0.809	
SE_1				0.832
SE_2				0.802
SE_3				0.646
PA_1			0.745	

The values presented in Table 1 indicate that statement items with values ≥ 0.70 are considered highly valid. Meanwhile, other question items with values between ≥ 0.50 to 0.60 are considered sufficiently valid.

Average Variance Extracted (AVE)

The Average Variance Extracted (AVE) serves to explain the questionnaire's reliability, considered reliable if the AVE value is greater than 0.5. Convergent validity indicates that a set of indicators reflects a latent variable and represents its underlying aspects. This representation can be demonstrated through measurability with the extracted AVE average variance values. The obtained AVE values can be presented in the following table.

From the data listed in the table, it can be concluded that the overall AVE values are greater than 0.50. This indicates an adequate level of validity. The results of the Smart PLS analysis in the table show that the lowest AVE value is 0.585 for the PA variable, while the highest AVE

value is 0.715 for the CT variable.

Table 2.
Average Variance Extracted (AVE) Test Results

	Average variance extracted (AVE)
AG_	0.636
CT_	0.715
PA	0.594
SE_	0.585

Discriminant Validity

Discriminant Validity is a measurement model that uses reflective indicators and is evaluated based on cross-loading measurements between indicators and their constructs. If the correlation between constructs and measurement indicators is higher than the correlation with other constructs, it indicates that the measurement block is better than the others. Another method to assess discriminant validity is by comparing the square root values of the average variance extracted (AVE). From the calculation results in Smart PLS, the following data are obtained:

Table 3.
Discriminant Validity Test Results

	AG_	CT_	PA_	SE_
AG_				
CT_	0.943			
PA_	1.104	0.883		
SE_	0.949	0.947	1.002	

These numbers reflect the cross-loading values, which are useful in determining whether a construct has adequate discriminant validity. This is done by comparing the loading values on the construct being tested, which should be higher than the loading values on other constructs.

Reliability Testing

Composite Reliability

Composite reliability is a parameter used to measure the reliability of a construct and can be found in the latent variable coefficient display. There are two evaluation methods for composite reliability, namely internal consistency and Cronbach's alpha. If the obtained value exceeds 0.80, the construct is considered to have high reliability.

Table 4.
Composite Reliability Test Results

	Composite reliability (rho_c)	Information
AG_	0.839	Reliabel
CT_	0.938	Reliabel
PA	0.864	Reliabel
SE_	0.807	Reliabel

The values above indicate that all variables are proven to have reliability with Composite Reliability values ≥0.70. The SE variable has the lowest Composite Reliability value at 0.807, while the CT variable has the highest value at 0.938. These values are greater than the criteria for Composite Reliability exceeding 0.8, indicating a high level of reliability.

Cronbach's Alpha

Cronbach's Alpha is a reliability test used to reinforce findings from composite reliability. A variable is considered reliable if its Cronbach's Alpha value is greater than 0.7. The explanation of Cronbach's Alpha values can be seen in the following table:

Table 5.
Cronbach's Alpha Value

	Cronbach's alpha	Keterangan
AG_	0.711	Reliabel
CT_	0.920	Reliabel
PA	0.813	Reliabel
SE_	0.738	Reliabel

Based on Table 5, Cronbach's Alpha values obtained from the analysis using Smart PLS are all above 0.7. Therefore, it can be explained that the questionnaire has reliability for use in research. It can be concluded that the questionnaire is reliable.

Inner Model Testing (Structural Model)

Coefficients of Determination (R-square)

The test on the structural model is carried out to evaluate the relationships between latent constructs through R-Square (R2) testing. The R Square values indicate the coefficient of determination on endogenous constructs. The interpretation of R Square values is 0.67 (strong), 0.33 (moderate), and 0.19 (weak) (Chicco et al., 2021). The R2 test is used to assess the extent to which the variation in independent variables influences the dependent variable. The following are the results of the R2 values used to measure the level of variation in changes. For more details, refer to the table below:

Table 6.
R-square Value

	R-square	R-square adjusted
AG_	0.753	0.753
CT_	0.672	0.672
SE_	0.508	0.508

Based on the displayed table, it can be concluded that the R-Square value for the AG variable is 0.753, indicating that 75.3% of the variation in the AG variable can be explained by the PA variable, while the remaining 24.7% is influenced by other factors outside the scope of this study. Meanwhile, the R2 value for the CT variable is 0.672, indicating that 67.2% of the variation in the CT variable can be explained by the PA variable, with the remaining 32.8% influenced by other factors outside the research model. Furthermore, the R2 value for the SE variable is 0.508, indicating that 50.8% of the variation in the SE variable can be explained by the PA variable, with the remaining 49.2% influenced by other factors outside the research model.

F-square

In f-Square testing, the aim is to assess the extent to which independent latent constructs relatively influence their dependent latent constructs. The criteria for f-Square testing are as follows: (1) If the f-Square value < 0.02, then

the relationship between the constructs is considered low, (2) If the f-Square value > 0.15, then the relationship between the constructs is considered moderate, (3) If the f-Square value > 0.35, then the relationship between the constructs is considered strong (David Garson, 2016). The criteria for f-Square values can be explained in the following table:

Table 7.
F-square Value

	AG_	CT_	PA_	SE_
AG_				
CT_				
PA_	1.406	0.400		1.033
SE_	0.003	0.203		

Based on the Smart PLS analysis above, the f-square values for each variable have been explained and found. Referring to the Decision Criteria, there are values for variables to assess their independent latent constructs.

Path Coefficients, T-Statistics, dan P-Value

The t-statistic values from the estimation of path coefficients are used to test the strength of the influence between variables and indicate the extent of the relationship between the directions of those variables. Relevant information can be found in the following table:

Table 8.
Path Coeffecients Test Results

	Ori sample (O)	mean (M)	(SD)	T statistics (|O/STDEV|)	P values
PA -> AG_	0.840	0.837	0.027	31.114	0.000
PA -> CT_	0.516	0.518	0.035	14.873	0.000
PA -> SE_	0.713	0.713	0.020	36.417	0.000
SE_ -> AG_	0.039	0.042	0.029	1.332	0.183
SE_ -> CT_	0.368	0.367	0.036	10.267	0.000

Table 9.
Value of Moderating Influence

	Ori sample (O)	mean (M)	(SD)	T statistics	P values
SE_ x PA -> AG_	-0.048	-0.049	0.013	3.787	0.000
SE_ x PA -> CT_	0.041	0.040	0.017	2.448	0.014

Table 8 represents the results of the Smart PLS analysis, providing Path Coefficients, T-Statistics, and P-Value. Before analyzing these results, the t-table value is needed as a comparison to the p-value with a degree of freedom of 809. Thus, the t-table value obtained is 1.963. Based on the estimation table of path coefficients that presents P-Value, the hypotheses can be interpreted as follows:

1. The influence of PA on AG, based on the results of the testing in Table 8, shows a P-Value of 0.000, which is smaller than 0.05 (P-Value = 0.000 < 0.05). Therefore, it can be stated that there is a significant influence. This is supported by the t-statistic value of 14.873 > 1.963 (t-table), so it can be concluded that there is a significant influence of PA on CT with a confidence level of 95%.
2. The influence of PA on CT, based on the results of the testing in Table 8, shows a P-Value of 0.000, which is smaller than 0.05 (P-Value = 0.000 < 0.05). Therefore, it can be stated that there is a significant influence. This is supported by the t-statistic value of 31.114 > 1.963 (t-table), so it can be concluded that there is a significant influence of PA on AG with a confidence level of 95%.
3. The influence of PA on SE, based on the results of the testing in Table 8, shows a P-Value of 0.000, which is smaller than 0.05 (P-Value = 0.000 < 0.05). Therefore, it can be stated that there is a significant influence. This is supported by the t-statistic value of 36.417 > 1.963 (t-table), so it can be concluded that there is a significant influence of PA on AG with a confidence level of 95%.
4. The influence of SE on AG, based on the results of the testing in Table 8, shows a P-Value of 0.183, which is larger than 0.05 (P-Value = 0.183 > 0.05). Therefore, it can be stated that there is no significant influence. This is supported by the t-statistic value of 1.332 < 1.963 (t-table), so it can be concluded that there is no significant influence of SE on AG with a confidence level of 95%.
5. The influence of SE on CT, based on the results of the testing in Table 8, shows a P-Value of 0.000, which is smaller than 0.05 (P-Value = 0.000 < 0.05). Therefore, it can be stated that there is a significant influence. This is supported by the t-statistic value of 10.267 > 1.963 (t-table), so it can be concluded that there is a significant influence of SE on AG with a confidence level of 95%.
6. The influence of PA on AG through SE (testing moderation effects), based on Table 9, shows a P-Value of 0.000, which is smaller than 0.05 (P-Value = 0.000 < 0.05). Therefore, it can be stated that there is an influence of PA on AG through SE with a t-statistic comparison > t-table (3.787 > 1.963). Thus, it can be concluded that there is an influence of PA on AG through SE with moderation effects and a confidence level of 95%.

The influence of PA on CT through SE (testing moderation effects), based on Table 9, shows a P-Value of 0.014, which is smaller than 0.05 (P-Value = 0.014 < 0.05). Therefore, it can be stated that there is an influence of PA on CT through SE with a t-statistic comparison > t-table (2.448 > 1.963). Thus, it can be concluded that there is an influence of PA on CT through SE with moderation effects and a confidence level of 95%.

Discussion

Physical activity (PA) has an impact on students' Academic grades (AG) in the process of growth and development. Indirectly, PA contributes to improving and enhancing AG (Kwak et al., 2009; Lorenz et al., 2017; Tremblay et al., 2000). It is further explained that PA provides the best contribution to the developmental learning process in Physical Education as a facility to enhance values in education (Mercier et al., 2023). In terms of its influence on cognitive function, PA enhances the flow of blood to the brain, facilitating smoother oxygen supply to support the growth of nerve cells (Chen & Nakagawa, 2023; Xu et al., 2023). This process can enhance cognitive function in humans to process stimuli, information, improve concentration, and sharpen memory. This mechanism indirectly influences AG in children. Another explanation of the positive value of PA

can be seen from the level of stress reduction in children, which can enhance AG. PA helps reduce stress and anxiety levels, which can disrupt focus and academic performance (Sanchez et al., 2023; Wang et al., 2023). Therefore, PA helps children cope with academic pressure and increases motivation. Involvement in structured physical activities helps develop discipline and time management, allowing students to be more effective in learning and completing tasks. Considering the explanations above, it is plausible that PA plays a significant role in the success of children in learning and AG.

PA has a positive contribution to Critical Thinking (CT) in the context of children's AG. CT holds a significant place in daily life, whether at school, in society, or within the family. It is evident that PA has a positive impact on CT, as seen from the results of the analysis. Numerous studies have explored the influence of PA on CT in primary school children (Başaran & Bay, 2023; Christine Berg & Taff, 2023; Leggett, 2022; Schoeller, 2023).

Physiologically, it is clear that PA has an impact on CT, as through PA, it can provide stimulus for the release of neurotransmitters (such as dopamine, serotonin, and norepinephrine) and hormones (endorphins). This enhances mood, motivation, and alertness, supporting critical thinking abilities (Drăgoi et al., 2024; Matei et al., 2023; Popa et al., 2023). Additionally, physical activity stimulates the production of brain-derived neurotrophic factor (BDNF), supporting the growth and maintenance of brain cells, which can enhance critical thinking and memory abilities (Abdulghani et al., 2023; Cefis et al., 2023). Physical activity involving coordination and strategy provides numerous benefits in the development of cognitive skills. Brain exercises in tactical problem-solving, quick and accurate analysis of situations, planning skills development in activities requiring strategy, motor coordination improvement through sports or dance, and the formation of high levels of concentration and focus are some of the advantages. Through various forms of PA, cognitive aspects can be stimulated and strengthened, providing benefits not only for physical health but also for the development of critical thinking and analytical skills crucial in daily life.

Based on the discussion above, the crucial role of PA can be considered a separate strategy in accompanying the development and growth of children. Considering children's characteristic of being active, it is relatively easy to use approaches that can provide quality PA for children. Consequently, CT and AG, as key assessments of a child's developmental aspects, can be achieved.

Conclusion

The study utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS software, conducting a thorough analysis in two stages: Outer Model Evaluation and Inner Model Evaluation. Validity and reliability testing, including Convergent Validity, AVE, Discriminant Validity, Composite Reliability, and Cronbach's Alpha, were applied to ensure the quality of the data. Validity testing revealed high validity, with loading factor values ≥ 0.70 for most statement items and sufficiently valid values between 0.50 and 0.60. AVE values exceeding 0.50 demonstrated adequate validity. Discriminant Validity, as assessed through cross-loading measurements, and high Composite Reliability values confirmed questionnaire reliability. In Inner Model Testing, R-square values indicated substantial variation explained in endogenous constructs, with PA significantly influencing AG, CT, and SE. F-square values demonstrated the strength of relationships, highlighting PA's significant influence on AG and CT. Path coefficients, t-statistics, and p-values provided insights into the significance of relationships, with PA significantly influencing AG, CT, and SE. The moderation effects of SE on relationships were also significant. The discussion emphasized the positive impact of PA on AG and CT in children, attributing it to physiological mechanisms, stress reduction, and cognitive stimulation. In summary, the study's findings support the significance of PA in enhancing AG and CT in children, offering a robust understanding of the interplay between physical activity, academic performance, and cognitive development

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Conflicts of interest

The authors declare no conflicts of interest.

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