

The Relationship Between Fundamental Motor Skills and Spatial Perception in Children Aged 6–9: A Correlational Study

العلاقة بين المهارات الحركية الأساسية والإدراك المكاني لدى الأطفال من سن 6 إلى 9 سنوات: دراسة ارتباطية

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Abstract: This study explored the relationship between fundamental motor skills—specifically locomotor skills, balance, and object control—and spatial perception in children aged 6 to 9 years. A descriptive correlational design was employed with a sample of 253 primary school pupils from Biskra's second educational district during the 2024/2025 academic year. Fundamental motor skills were assessed using the UQAC–UQAM (2011) test battery, and spatial perception was quantified using a modified version of the tool developed by Al-Suwaidani (2018). The findings revealed significant positive correlations between motor skills and spatial perception, highlighting the influence of motor development on cognitive abilities in middle childhood. Based on these results, the study recommends integrating systematically designed movement activities into primary school physical education curricula to promote the joint development of motor and cognitive skills in children

Keywords: Fundamental motor skills; Spatial perception; Middle childhood.

المخلص: هدفت هذه الدراسة إلى تحليل العلاقة بين المهارات الحركية الأساسية (الانتقالية، التوازن، والتحكم بالأدوات) والإدراك المكاني لدى الأطفال في مرحلة الطفولة المتوسطة (6-9 سنوات). طُبقت الدراسة على عينة عنقودية من (253) تلميذاً وتلميذة بالمرحلة الابتدائية في مدينة بسكرة، باستخدام المنهج الوصفي الارتباطي. واعتمدت على البطارية الاختبارية (UQAC–UQAM, 2011) لتقويم المهارات الحركية، ونسخة معدلة من أداة السويداني (2018) لقياس الإدراك المكاني. أسفرت النتائج عن وجود علاقات ارتباطية موجبة ذات دلالة إحصائية بين جميع أبعاد المهارات الحركية والإدراك المكاني، مما يؤكد دور النمو الحركي في تنمية القدرات المعرفية خلال مرحلة الطفولة المتوسطة. وفي ضوء هذه النتائج توصي الدراسة بإدماج أنشطة حركية هادفة ومنظمة في مناهج التربية البدنية المدرسية لتعزيز التكامل بين النمو الحركي والمعرفي.

الكلمات المفتاحية: المهارات الحركية الأساسية؛ الإدراك المكاني؛ الطفولة المتوسطة.

Theoretical Chapter

1. Introduction and Problem Statement

Fundamental Motor Skills (FMS)—such as locomotor movements, balance, and object control—are considered crucial during the early stages of childhood, as they form the core foundation for acquiring more complex motor patterns and higher-order cognitive abilities later in development (Gallahue & Ozmun, 2006). At the same time, spatial perception constitutes an essential component of cognitive functioning, shaping skills related to reasoning, memory processes, and mathematical understanding (Scott et al., 2023).

Recent research has increasingly demonstrated positive associations between motor competence and cognitive growth in children, highlighting that participation in complex motor tasks can stimulate executive functions and foster neural connectivity (Shi & Feng, 2022). Supporting this view, Mihoubi (2024) reported that motor education enhances not only physical proficiency but also communication and social cognition. In a similar vein, Scott et al. (2023) found that intrinsic static spatial ability mediates the relationship between motor skill proficiency and outcomes in physical conditioning tasks among children aged 7–8 years.

These insights align with the framework of Embodied Cognition Theory, which argues that physical interaction with the environment strengthens spatial and visual learning (Eleanor Gibson, as cited in Wilson, 2002). In parallel, Dynamic Systems Theory highlights how motor behavior—such as balancing or coordinating movements—emerges from self-organizing processes that integrate sensory, motor, and cognitive systems (Smith & Thelen, 2003).

Despite growing evidence linking motor skills with cognitive development, the specific interplay between fundamental motor skills and spatial perception in children aged 6 to 9 remains underexplored. Moreover, prior studies have often emphasized academic outcomes in general, without isolating the motor domains most directly connected to spatial perception.

Therefore, the present study seeks to investigate the following central research question:

Is there a statistically significant correlation between fundamental motor skills (locomotor, balance, and control skills) and spatial perception among primary school children aged 6 to 9? Additionally, can either of these variables predict the development of the other?

From this main question, the following sub-questions emerge:

1. Is there a statistically significant relationship between locomotor skills and spatial perception among children aged 6 to 9?
2. Is there a statistically significant relationship between balance skills and spatial perception in the study sample?
3. Is there a statistically significant relationship between control skills and spatial perception among children aged 6 to 9?

The study posits that a significant positive correlation exists between the level of fundamental motor skills and spatial perception in children within the target age range. More specifically, the study hypothesizes that:

1. Locomotor skills are positively correlated with spatial perception.
2. Balance skills are positively correlated with spatial perception.
3. Control skills are positively correlated with spatial perception.

The study's purpose is to examine the nature of the relationship between fundamental motor skills and spatial perception among primary school children aged 6 to 9. It seeks to:

1. Analyze how locomotor skills relate to spatial perception.
2. Investigate the association between balance and spatial perception.
3. Explore the link between motor control skills and spatial perception.

This study is of significance on multiple levels:

Scientific and Theoretical Relevance

This study adds to the literature in movement science and education by elucidating the interaction between motor and cognitive domains during a critical stage of childhood. As highlighted by Smith and Thelen (2003), motor development is intrinsically linked to cognitive growth, forming part of a dynamically integrated system rather than functioning in isolation

Educational and Practical Relevance

Findings may inform educators and movement specialists in designing integrated learning programs that combine physical activity with cognitive challenges to improve spatial abilities. Furthermore, the results can guide early intervention strategies for children showing developmental delays in either domain, based on the patterns revealed through this research.

2- Key Concepts and Operational Definitions

2- 1-Fundamental Motor Skills

Fundamental Motor Skills (FMS) are essential building blocks that support the development of more complex motor abilities throughout life. Gallahue and Ozmun (2006) classify these skills into three categories:

- Locomotor skills – running, jumping, hopping.
- Stability skills – bending, turning, maintaining balance.
- Object control skills – throwing, catching, kicking.

These skills are vital for motor competence and help children engage in various physical and sports activities. Haywood and Getchell (2019) emphasize that FMS are not innate but develop gradually through interaction with the environment,

guided practice, and training. Inadequate development of these skills during childhood may limit participation in physical education and sports later in life, potentially affecting children's physical fitness and psychosocial well-being. They also contribute to self-confidence, social interaction, and long-term participation in physical activity.

In sum, FMS are central to motor development and play a key role not only in physical health but also in academic achievement, particularly during early and middle childhood.

In this study, FMS are operationally defined as children's performance on the UQAC–UQAM test battery, which assesses locomotor, object control, and balance skills, focusing on movement accuracy and organization.

2-2-Spatial Perception

Spatial perception is a cognitive ability that enables individuals to understand spatial relationships between objects and navigate their environment. Bouterfas & Taouinat (2023) defines it as the ability to perceive the position, movement, and arrangement of spatial objects relative to oneself and others. Similarly, the Oxford Dictionary of Psychology (Coleman, 2015) describes it as “the process of becoming aware of the locations and relationships of objects in space”.

Hart and Moore (1973), cited in Albader (2022), define it as “the internal knowledge and representation of spatial structure, entities, and relationships,” emphasizing its cognitive and representational aspects beyond mere visual input. Developing spatial perception allows children to build mental maps, perform geometric reasoning, and improve their understanding of distances and directions—skills that are important both academically and functionally.

Thus, spatial perception is essential not only for physical orientation and motor coordination but also for broader cognitive development during childhood.

In this study, spatial perception is operationally defined as children's performance on the subtests of Al-Suwaidani's spatial perception test, which assess their ability to perceive, organize, and interpret spatial relationships

Practical Chapter

1- Followed Methodologies

1-1-Field of the Study

This study was situated within the field of kinesiology and motor development, with a specific focus on the interplay between motor and perceptual growth during middle childhood. It targeted children aged 6 to 9 years enrolled in primary schools within the second educational district of Biskra, during the 2024/2025 academic year. The school environment was purposefully selected due to its alignment with the developmental stages of fundamental motor skills and spatial perception—core elements of physical education and early learning programs. The research supports current educational trends emphasizing the integration of movement-based learning into school curricula and highlights the critical role of motor–perceptual interactions in fostering holistic child development

1-2-Adopted Method

This study employed the descriptive correlational method, as it is the most appropriate approach for identifying the nature of the relationship between two or more variables without any interference from the researcher. In this method, variables are observed as they naturally occur in their environment, and the statistical relationships between them are analyzed.

This aligns with what Farhat & Abu Zaid (2022) indicated—that the descriptive correlational approach is used to examine relationships between variables

within their real-world context, which corresponds to the objectives of the present study

1-3-Population and Sample.

In alignment with the objectives and nature of this research, the target population consisted of all primary school pupils aged between 6 and 9 years enrolled in schools operating under the second educational district of Biskra Province during the 2024–2025 academic year. This age group corresponds to students in grades 1 to 3 of primary education and is characterized by critical developmental milestones in both motor and perceptual domains.

The total number of pupils in this population was 3,680, providing a broad and relevant base for examining relationships between fundamental motor skills and spatial perception. These pupils were considered appropriate for applying the selected measurement tools, namely the UQAC–UQAM (2011) test battery for motor skills and a modified version of Al-Suwaidani's (2018) test for spatial perception.

To ensure representativeness, a multi-stage cluster sampling technique was employed, as detailed below.

1-4-Sampling Technique

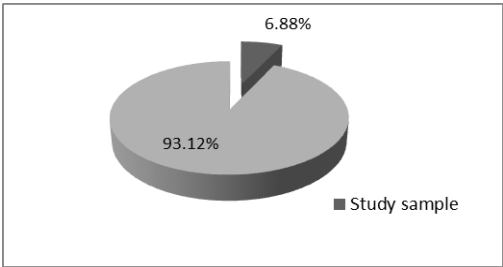
The sampling process was conducted using a **multi-stage cluster sampling method**, which is well-suited for large, geographically dispersed educational populations (Creswell & Creswell, 2018). The sampling procedure unfolded as follows:

- **Stage 1:** Several primary schools within the second district of Biskra were randomly selected.
- **Stage 2:** Within each selected school, specific classrooms corresponding to the target age group (6–9 years) were chosen.

- **Stage 3:** Finally, a simple random sampling technique was applied to select individual pupils from the chosen classrooms.

This rigorous procedure resulted in a final sample of 253 students, comprising 112 boys and 141 girls, representing approximately 6.88% of the total population. As shown in Figure 1

Fig 1. Representation of the Sample Relative to the Total Population



To verify the homogeneity of the sample by age, the following descriptive statistics were calculated:

Table 1. Distribution of Sample by Age Group (in years) and Calculation of Weighted Mean

Age Group (Years)	Frequency	Midpoint (Mf)	f × Mf
6 – <7	102	6.5	663.0
7 – <8	86	7.5	645.0
8 – <9	65	8.5	552.5
Total	253		1860.5

The **arithmetic mean** of the sample was $\bar{x}=7.35$ years, and the **standard deviation** was $SD=\pm 0.80$

1-5-Tools for Data Collection

To achieve the objectives of the study, two primary tools were employed:

a. Fundamental Motor Skills Assessment Tool:

A battery of motor tasks derived from the UQAC-UQAM (2011) test protocol—accessed through Guy’s (2014) thesis—was employed. This battery assesses fundamental motor skills, including locomotor, balance, and object control abilities, using playful and age-appropriate tasks for children aged 6 to 9. The selected tests included side-step running, zigzag running, circular path running, one-leg balance, unstable surface balance, hand-foot coordination, and eye-hand coordination

b. Spatial Perception Assessment Tool:

Spatial perception was assessed using a modified version of Al-Suwaidani’s (2018) Spatial Perception Test. The adapted version included subtests measuring direction discrimination, spatial relationships, and position in space. Each subtest utilized developmentally appropriate visual stimuli and interactive tasks designed to capture children’s ability to perceive, organize, and interpret spatial information with reliability and validity.

1-6-Scientific Tool Conditions

The scientific adequacy of the tools was verified through both **validity** and **reliability** measures:

- **Content Validity:**

A panel of six experts in motor behavior and education at the University of Biskra reviewed the preliminary version of both instruments. They assessed the relevance of each item to the study’s goals and target age group. Only tests with an expert agreement rate exceeding 80% were retained. The finalized battery included eight motor tests and three spatial perception indicators.

- **Self-Validity and Reliability:**

Self-validity was estimated by extracting the square root of each test’s reliability coefficient. Reliability was determined using a test-retest

procedure with a 15-day interval, applied to the same standardization sample. Pearson's correlation coefficient was used to calculate the reliability values. All results indicated strong psychometric properties, with reliability coefficients ranging from 0.72 to 0.83 and self-validity values from 0.85 to 0.91.

1-7-Application Procedures

The fieldwork followed standardized procedures to ensure consistency and accuracy:

- Tests were administered individually in the children's regular school setting to promote comfort and reduce anxiety.
- Clear verbal and visual instructions, along with demonstrations, were given before each task.
- Testing conditions (task order, timing, instructions) were kept uniform across participants.
- Sessions of 24 children were conducted outside class hours to avoid disrupting school schedules; each session lasted 90–120 minutes.
- Parental consent was obtained before data collection, and all procedures complied with ethical standards

1-8-Statistical Methods Used

The statistical analysis of the study data was conducted using IBM SPSS Statistics (Version 26). Prior to hypothesis testing, the Kolmogorov–Smirnov test was applied to verify that the data met the assumption of normality.

To test the research hypotheses, Pearson correlation coefficients were calculated in order to examine the relationship between the level of fundamental motor skills (including locomotor, balance, and motor control abilities) and spatial perception in children aged 6 to 9 years.

A significance level of 0.05 was adopted to determine the statistical significance of the results

2-Exposure, Analysis and Result Examination

2-1-Presentation of Results

This section presents and analyzes the study results according to the hypotheses, in order to examine the relationship between the dimensions of fundamental motor skills (locomotor, balance, and control skills) and indicators of spatial perception (direction discrimination, spatial relations, and position in space) among primary school children aged 6 to 9.

Pearson's correlation coefficient (Pearson's r) was used to measure the strength of the relationship between variables, after confirming that the data followed a normal distribution. A separate correlation table was allocated for each hypothesis, followed by a graphical representation and a simplified statistical and pedagogical analysis, interpreted in light of relevant scientific literature and the theoretical framework.

a. First hypothesis

"There is a positive correlation between locomotor skills and spatial perception in children aged 6–9 years".

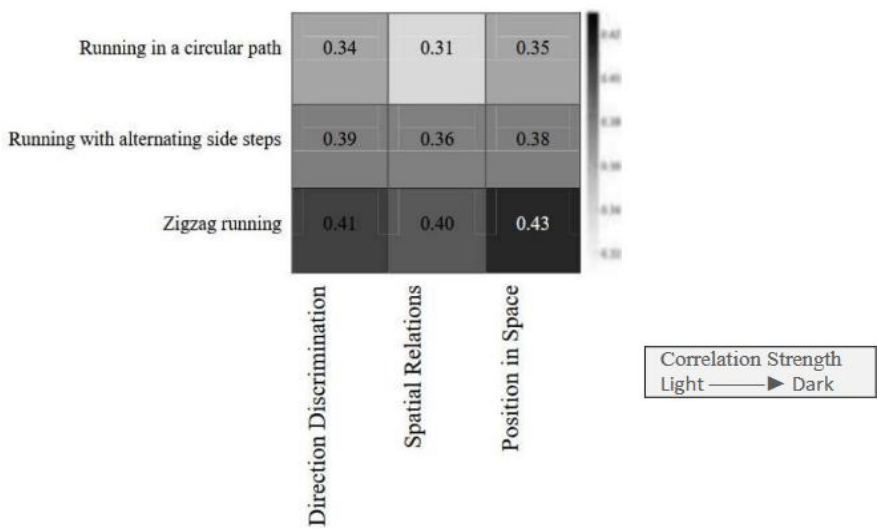
To test this hypothesis, Pearson correlation coefficients were calculated between the children's results in locomotor skill tests and indicators of spatial perception, after verifying the normal distribution of the data. The results are presented in the following table

Table 2. Correlation Matrix between Locomotor Motor Skills and Spatial Perception Indicators

Locomotor Motor Skills	Direction Discrimination	Spatial Relations	Position in Space
Running in a circular path	$r = 0.34^*$	$r = 0.31^*$	$r = 0.35^*$
Running with alternating side steps	$r = 0.39^{**}$	$r = 0.36^*$	$r = 0.38^{**}$
Zigzag running	$r = 0.41^{**}$	$r = 0.40^{**}$	$r = 0.43^{**}$

(*) $p < 0.05 = statistically\ significant$, (**) $p < 0.01 = highly\ statistically$

Fig 2. Heat map of the relationship between Locomotor Motor Skills and spatial perception indicators



Statistical Analysis and Interpretation

- All correlation coefficients are positive, indicating a direct relationship between locomotor motor skills and spatial perception indicators.

- The strongest correlations were found with zigzag running, with r-values ranging from 0.40 to 0.43 at a high significance level ($p < 0.01$).
- Running with alternating side steps also showed moderate to moderately strong correlations ($r = 0.36\text{--}0.39$), all statistically significant.
- Running in a circular path demonstrated weaker but still significant correlations ($p < 0.05$) with all spatial perception measures.

Motor and Educational Interpretation

Locomotor activities—especially zigzag running—require children to make rapid spatial judgments and precise motor decisions in dynamic environments, which may enhance spatial perception mechanisms.

Children engaged in these types of movement patterns often display greater awareness of movement direction and spatial relationships with surrounding objects.

Thus, locomotor skills may serve as implicit cognitive correlates that support the development of spatial perception, as they involve the continuous synchronization of motor actions with spatial variables in the environment

b. Second hypothesis

“There is a positive correlation between balance skills and spatial perception in children aged 6–9 years.”

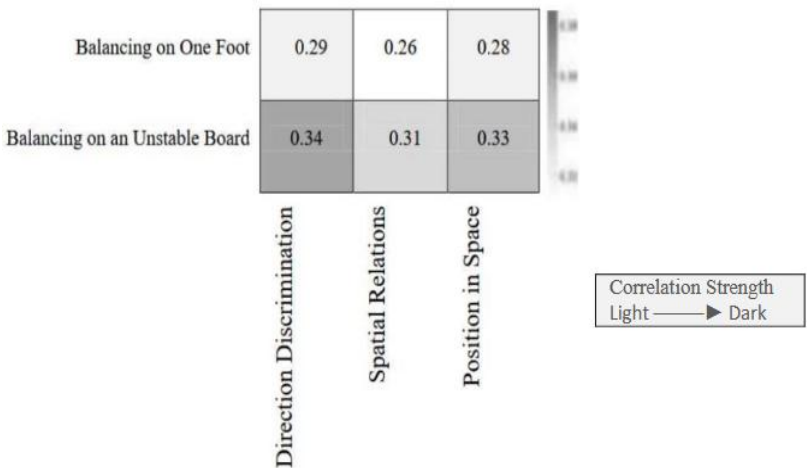
To test this hypothesis, correlation coefficients were calculated between children’s results in balance skill tests and spatial perception indicators using Pearson’s r , after verifying the normal distribution of the data. The results are shown in the table below

Table 3. Correlation Matrix Between Balance Motor Skills and Spatial Perception Indicators

Balance Motor Skills	Direction Discrimination	Spatial Relationships	Position in Space
Balancing on One Foot	$r = 0.29^*$	$r = 0.26^*$	$r = 0.28^*$
Balancing on an Unstable Board	$r = 0.34^{**}$	$r = 0.31^*$	$r = 0.33^{**}$

(*) $p < 0.05$ = statistically significant, (**) $p < 0.01$ = highly statistically significant

Fig 3. Heat map of the relationship between balance skills and spatial perception indicators



Statistical Analysis and Interpretation

- The results show that both balance tests are positively and significantly correlated with all indicators of spatial perception.
- The correlation coefficients between balance on an unstable surface and the spatial perception indicators are higher than those for balance on one foot.

- The highest correlation was recorded between balance on an unstable surface and direction discrimination ($r = 0.34$, $p < 0.01$), indicating a moderate but statistically significant relationship.

Motor and Educational Interpretation

These findings indicate that balance abilities are closely tied to spatial awareness, as activities on unstable surfaces activate multiple sensory systems and reinforce the child's internal spatial representation

In educational contexts, integrating structured balance activities—such as beam walking or wobble boards—offers a practical way to support both motor development and spatial-cognitive skills essential for tasks like handwriting, geometry, and navigation.

Given the neural plasticity during ages 6 to 9, balance training should be considered a key component of programs aiming to foster holistic child development.

Moreover, balance-focused activities can be easily adapted to classroom or playground settings, making them accessible tools for educators enhancing children's spatial orientation and academic readiness

c. The third hypothesis:

“There is a positive correlation between motor control skills and spatial perception in children aged 6–9 years. ”

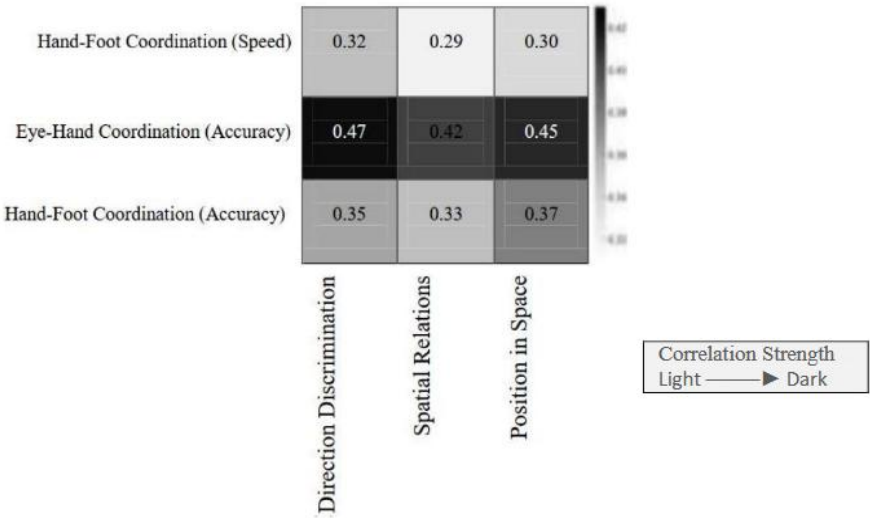
To verify this hypothesis, Pearson correlation coefficients were calculated between the children's scores in the motor control skill tests and the indicators of spatial perception, after confirming that the data distribution was normal. The results are presented in the table below

Table 4. Correlation Matrix between Control Motor Skills and Spatial Perception Indicators

Control Motor Skills	Direction Discrimination	Spatial Relations	Position in Space
Hand-Foot Coordination (Speed)	$r = 0.32^*$	$r = 0.29^*$	$r = 0.30^*$
Eye-Hand Coordination (Accuracy)	$r = 0.47^{**}$	$r = 0.42^{**}$	$r = 0.45^{**}$
Hand-Foot Coordination (Accuracy)	$r = 0.35^*$	$r = 0.33^*$	$r = 0.37^*$

(*) $p < 0.05$ = statistically significant, (**) $p < 0.01$ = highly statistically significant

Fig 4. Heat map of the relationship between Control Motor Skills and spatial perception indicators



Statistical Analysis and Interpretation

- The correlation matrix indicates that all control motor skills are positively and significantly associated with spatial perception indicators.

- Correlation coefficients ranged from 0.29 to 0.47, reflecting moderate to moderately strong relationships.
- Notably, eye-hand coordination (precision) demonstrated the strongest correlations with all spatial indicators ($r = 0.42\text{--}0.47$, $p < 0.01$).
- Hand-foot coordination (both speed and accuracy) also showed statistically significant, but comparatively weaker, correlations ($p < 0.05$).

Motor and Educational Interpretation

These results suggest that children with more advanced fine motor control—particularly in tasks requiring precise eye–hand coordination—also tend to perform better in spatial perception tasks such as direction discrimination, spatial relationships, and position in space.

Accurate motor control depends on continuous visual and spatial feedback, training the brain to interpret and respond to spatial cues more effectively.

For example, a child who can accurately catch or throw a ball is constantly adjusting their actions based on the ball's position, which enhances both self-relative and object-relative spatial awareness.

In educational settings, promoting eye–hand coordination through purposeful activities—such as drawing, construction play, or ball games—can help support spatial reasoning skills that are foundational for academic learning.

2-2-Discussion of the Results

The study of the relationship between fundamental motor skills and spatial perception indicators revealed statistically significant and positive correlations across all three hypotheses. Pearson correlation coefficients ranged from 0.26 to 0.47, indicating, according to Gignac and Szodorai (2016), relationships ranging from weak-to-moderate to moderately strong. These results support the general

hypothesis that motor skills are associated with the development of spatial perception in primary school children aged 6–9 years.

a. Locomotor Skills and Spatial Perception

- Moderate to moderately strong correlations ($r \approx 0.31\text{--}0.43$) were observed between locomotor skills and spatial perception indicators.
- These results are in line with research by Logan et al. (2012) and Uttal et al. (2013), which emphasized the role of motor interaction in shaping the structure of spatial cognition.
- According to Piagetian theory, children's active locomotor experiences (such as zigzag or circular running) may generate neural input that contributes to dynamic and evolving spatial awareness, even though the relationship is correlational rather than causal.

b. Balance Skills and Spatial Perception

- Correlation values ranging from $r = 0.26$ to 0.34 indicate moderate relationships.
- These findings are consistent with those of Frick & Möhring (2016), who reported that balance skills predict spatial perception even after accounting for cognitive factors such as intelligence and memory.
- From the perspective of embodied cognition, balance tasks activate neural mechanisms that process visuo-sensory and vestibular input, thus facilitating spatial processing via the central nervous system (Wilson, 2002).
- Psychomotor theory further suggests that postural and emotional balance contribute to the formation of stable spatial representations, particularly during balance tasks performed on unstable surfaces.

c. motor control skills and Spatial Perception

- Visuomotor coordination showed correlation coefficients ranging from $r = 0.29$ to 0.47 with spatial perception indicators, suggesting moderate to moderately strong relationships.
- Studies by Butterworth & Laurillard (2017) and Wilson et al. (2002) support this finding, indicating that effective visuomotor coordination is closely associated with higher-order spatial-cognitive functioning.
- A plausible interpretation is that direction and position perception require fine motor precision in anticipating object locations relative to visual input—skills developed through targeted motor control activities.

Through the analysis of the correlation levels between fundamental motor skills and spatial perception indicators, control skills emerged as the most strongly associated. Eye–hand coordination, in particular, produced the highest correlation ($r = 0.47$), underscoring the importance of visuomotor integration in supporting spatial abilities.

Next in strength were locomotor skills, with a peak value of $r = 0.43$ observed in the zigzag running task, highlighting the role of dynamic movement and spatial orientation in developing spatial perception. Balance skills, while still statistically significant, showed lower correlations (highest $r = 0.34$ in the unstable board test), suggesting a more foundational, but relatively limited, contribution.

This gradient of association underscores the complementary nature of different motor performance components. Skills that involve precise control and demand active visual–sensory feedback—such as eye–hand coordination—appear to play a more prominent role in supporting spatial cognitive development during middle childhood.

Conclusion

This study confirmed a significant link between motor and cognitive development in children aged 6 to 9 years. All three types of fundamental motor skills—locomotor, balance, and especially control skills—were positively correlated with spatial perception indicators. Among them, control skills, particularly eye–hand coordination, demonstrated the strongest associations, underscoring the crucial role of visuomotor integration in supporting spatial awareness.

These findings highlight that motor development is not merely a physical domain but a foundational contributor to children's cognitive growth. As such, early education should not overlook the importance of integrating structured, developmentally appropriate motor activities. Doing so can foster spatial reasoning, enhance learning readiness, and support overall academic and social development.

Therefore, educators and curriculum designers are encouraged to adopt interdisciplinary approaches that link physical activity with cognitive stimulation. Promoting motor education as an essential component of early childhood learning may contribute significantly to a more holistic and effective educational experience.

Recommendations

Based on the above findings, the study recommends the following:

1. Emphasize the integration of fine motor activities (e.g., hand-eye coordination) into elementary school physical education programs.
2. Implement targeted educational programs aimed at developing fundamental motor skills as a gateway to enhancing spatial perception.
3. Provide teachers with practical training on motor-perceptual strategies through ongoing professional development.

4. Encourage active learning practices that integrate physical movement and spatial exploration into daily classroom routines, physical education sessions, and school playground activities
5. Involve parents by raising awareness about the importance of motor activities in early childhood cognitive development and providing guidance on home-based movement tasks.

Suggestions for Future Research

To deepen knowledge in this vital area, the study proposes the following:

1. Conduct experimental studies using pre-test/post-test designs to examine the causal effect of motor skills training on spatial perception.
2. Investigate gender- and age-related differences in the relationship between motor skills and spatial perception.
3. Explore the impact of digital tools and motor-based educational games on spatial skills in young learners.

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