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Senso-perceptive abilities and motor coordination in 8-9 year old children: evidence from a school-based study

Habilidades sensoperceptivas y coordinación motriz en niños de 8 a 9 años: evidencia de un estudio escolar

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Abstract

Gross motor coordination reflects the integration of sensori-motor processes, including visual-spatial orientation and proprioceptive feedback, which are essential for efficient movement execution during childhood. Disruptions in this integration may restrict participation in physical



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activity and adversely affect quality of life. The purpose of this study was to evaluate gross motor coordination in children aged 8-9 years and to examine potential gender-related differences in motor performance. A total of 145 children (74 boys and 71 girls) from public primary schools in the urban area of Shkodra, Albania, participated in the study. Gross motor coordination was assessed using the *Körperkoordinationstest für Kinder* (KTK), which includes the Backward Walking, Hopping for Height (Right and Left leg), Lateral Jumps, and Platform Shifting. Descriptive and inferential statistical analyses were conducted. Boys demonstrated significantly higher performance in Hopping Right ($p = .039$) and Platform Shifting ($p = .032$), whereas girls performed significantly better in Backward Walking ($p = .026$). Moderate to strong positive correlations were identified among the KTK subtests ($r = 0.40-0.70$), suggesting interrelated yet distinct dimensions of sensori-motor coordination. Overall, children in this age group exhibited a stable level of gross motor coordination with only minor gender-related differences. These findings provide region-specific evidence on sensori-motor development in early school-age children and support the inclusion of targeted sensori-motor coordination programs in primary school curricula.

Keywords: sensori-motor; motor activity; children; KTK; coordination

Resumen

La coordinación motriz gruesa refleja la integración de los procesos sensoriomotriz, incluyendo la orientación visoespacial y la retroalimentación propioceptiva, los cuales son esenciales para una ejecución eficiente del movimiento durante la infancia. Las alteraciones en esta integración pueden restringir la participación en la actividad física y afectar negativamente la calidad de vida. El propósito de este estudio fue evaluar la coordinación motriz gruesa en niños de 8 a 9 años y examinar las posibles diferencias asociadas al género en el rendimiento motor. Un total de 145 niños (74 niños y 71 niñas) de escuelas primarias públicas del área urbana de Shkodra, Albania, participaron en el estudio. La coordinación motriz gruesa se evaluó mediante el Test de Coordinación Corporal para Niños (KTK, por sus siglas en alemán), que incluye las subpruebas de Backward Walking, Platform Shifting, Hopping for Height y Lateral Jumps. Se realizaron análisis estadísticos descriptivos e inferenciales. Los niños mostraron un rendimiento significativamente mayor en Hopping Right ($p = .039$) y Transposición de Plataformas ($p = .032$), mientras que las niñas obtuvieron puntuaciones significativamente más altas en Backward Walking ($p = .026$). Se identificaron correlaciones positivas de moderadas a fuertes entre las subpruebas del KTK ($r = 0.40-0.70$), lo que sugiere dimensiones interrelacionadas pero distintas de la coordinación sensoriomotriz. En general, los niños de este grupo de edad exhibieron un nivel estable de coordinación motriz gruesa con solo sutiles diferencias relacionadas con el género. Estos hallazgos proporcionan evidencia específica de la región sobre el desarrollo sensoriomotriz en niños en edad escolar temprana y respaldan la inclusión de programas específicos de coordinación sensoriomotriz en los currículos de la escuela primaria.

Palabras clave: sensoriomotriz; actividad motriz; niños; KTK; coordinación



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Introduction

Nowadays, children's daily lives are increasingly characterized by insufficient physical and movement activity (Oliveira-Baleirón et al., 2026). Urbanization, excessive screen exposure, and the lack of adequate spaces for physical activity substantially limit opportunities for free movement (Stodden et al., 2008; Robinson et al., 2015; John et al., 2024). These constraints may negatively affect the development of movement competence and motor skills, which are essential for children's physical, cognitive, and social development.

Sensori-motor development constitutes a fundamental component of overall maturation in childhood, enabling children to process and integrate environmental information in order to guide motor actions effectively (Bustos et al., 2025). Between the ages of 8 and 9 years, the relationship between perception and movement becomes more stable and refined (Peqini et al., 2026). During this developmental stage, notable improvements occur in postural control, bilateral coordination, spatial and temporal perception, and attentional focus (Robinson et al., 2015). This period is particularly critical, as deficiencies in motor skill development may lead to long-term limitations in physical competence and reduced engagement in active lifestyles.

Children today grow up in a highly sensory-rich environment in which visual, auditory, tactile, and kinesthetic information must be continuously integrated. For children undergoing developmental processes, this integration is especially complex, as they rely heavily on sensory input to explore, learn, and understand their surroundings (Turgay & Sariberberoğlu, 2022). Core sensori-motor skills include spatial and temporal perception, body orientation, kinesthetic sensitivity, hand-eye coordination, bilateral coordination, and the ability to selectively attend to relevant stimuli while suppressing distractions. These skills develop progressively through the interaction of biological maturation and experiential learning within physical and social contexts (Payne & Isaacs, 2020).

Structured motor activities, such as movement-based games and individual or team sports, play a crucial role in enhancing sensory integration and coordinated motor execution (Ayres & Robbins, 2005). Consequently, numerous studies emphasize the importance of incorporating physical education programs early in childhood, not only to promote physical health but also to support cognitive and social development (Westendorp et al., 2011; Wilson



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et al., 2012). In primary education, sensori-motor abilities are closely associated with academic performance; for example, improved hand-eye coordination facilitates writing skills, while enhanced spatial perception supports orientation and navigation in new environments (Colella et al., 2020). Therefore, the assessment of these skills using standardized motor and perceptual tests represents a valuable approach for identifying developmental needs and planning early interventions (Velásquez et al., 2024).

Recent research indicates that evaluations of bilateral and lateral coordination, dynamic balance, spatial orientation, and motor reaction speed provide reliable indicators of sensori-motor development (Westendorp et al., 2011). Among the available assessment tools, the *Körperkoordinationstest für Kinder* (KTK) is widely used for children aged 8-9 years, offering a valid and reliable measure of gross motor coordination and supporting the identification of motor development profiles. Optimizing physical education in primary schools remains a research priority. In the Albanian context, Jarani et al. (2015) demonstrated that structured, thoughtfully designed physical activity programs significantly outperform standard routines in improving children's fitness and motor skills. Building upon this foundation, there is a critical need to explore more nuanced developmental areas, specifically how sensori-motor abilities interact with motor coordination. Investigating these components in 8-9 year olds offers a vital window to enhance a child's movement potential through tailored school-based interventions.

Methodology

This study began with the phase of identification and methodological planning, where initially 22 nine-year public schools in the municipality of Shkodra were identified, including a total of 30 third-grade classes and 586 students. From this total, three schools were randomly selected to represent geographic and socio-economic diversity. Within these schools, six third-grade classes were identified, comprising a total of 162 students.

Informed consent was obtained from parents or legal guardians for all participants, in accordance with the Declaration of Helsinki on ethical principles for research involving human subjects (World Medical Association, 1964) and the International Code of Medical Ethics. The study design follows the STROBE statement guidelines for cross-sectional studies. Permission



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to conduct the study was obtained from the Shkodra Local Office of Pre-University Education. Of the 162 students, 10 did not participate due to lack of parental approval, and 7 others changed schools during the study period. The final number consisted of 145 children, namely 74 boys and 71 girls.

Instruments

Motor coordination and sensori-motor skills were assessed using the Körperkoordinationstest für Kinder (KTK), a standardized and scientifically recognized instrument, suitable for children aged 5-14 years (Kiphard & Schilling, 1974; Novotná et al., 2025). Previous studies show high stability, reliability, and validity of the KTK for measuring gross motor coordination and sensorimotor development (Mardiansyah & Bakhtiar, 2023; Campbell-Pierre & Rhea, 2023).

KTK consists of four main subtests:

(1) Backward Walking (6, 4.5, and 3 cm) assesses dynamic balance and vestibular control.

(2) Platform Shifting (total number of moves in 20 seconds) assesses motor ability and bilateral coordination.

(3) Hopping for Height (best jump height for right and left leg) measures strength, coordination, and proprioceptive perception.

(4) Lateral Jumps (total number of lateral jumps in 15 seconds) assesses speed, rhythm, and spatial orientation.

In this study, KTK showed high internal consistency (Cronbach's $\alpha = 0.86$).

Procedure

All tests were conducted in the gymnasium of the University of Shkodra "Luigi Gurakuqi" during morning hours (09:00-12:00) to minimize fatigue. The tests were administered by six trained physical education specialists (volunteer students), who were specifically trained for the KTK test battery to ensure reliability. Each child received verbal



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instructions and a demonstration for each subtest, with 2-3 minute breaks between tests. Testing was stopped if the child showed signs of excessive fatigue, physical incapacity, or lack of motivation.

KTK data were recorded in individual files for each participant and then processed in Excel and IBM SPSS Statistics for Windows, version 26.0, IBM, SPSS Inc., Armonk, NY, USA for statistical analysis. These data help identify the current level of sensori-motor development and can also be used to create developmental profiles for educational programs and preventive interventions. Previous European studies show that children aged 8-9 years are highly responsive to interventions aimed at improving sensori-motor skills, which are important for school performance and sports participation (Bonafede & Van Der Merwe, 2023; Goodway et al., 2019; Wilson et al., 2012). Descriptive statistics were calculated for all variables. Normality was tested using the Shapiro-Wilk test. Gender differences were analyzed with *t*-tests for independent samples or Mann-Whitney U tests, as appropriate. Correlations between KTK subtests were analyzed using Pearson or Spearman coefficients. The level of statistical significance was set at $p < 0.05$.

Results

The results of this study show that 8-9 year old children of schools in the city of Shkodra have a stable level of motor coordination, measured through the Körperkoordinationstest für Kinder (KTK) test. The average performance in the different sub-tests suggests that sensory-perceptual skills are in the process of strengthening in this developmental period, although the differences between the sub-tests reflect different dimensions of perceptual and motor integration.



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TABLE 1. Descriptive statistics (Overall): Average, standard deviation, min, max, and quartile for each test. It gives the basic panorama of the performance of the entire sample.

Variable	count	mean	std	min	25%	50%	75%	max
Backward Walking	145.0	40.2	12.2	14.0	33.0	40.0	48.0	67.0
Hopping R	145.0	18.8	5.1	7.0	15.0	19.0	24.0	27.0
Hopping L	145.0	17.4	5.0	6.0	15.0	18.0	21.0	27.0
Lateral Jumps	145.0	26.1	5.8	11.0	23.0	26.0	30.0	43.0
Platform Shifting	145.0	8.5	1.8	5.0	7.0	9.0	10.0	17.0
Total	145.0	111.3	23.1	59.0	99.0	114.0	126.0	166.0

In Table 1, the descriptive statistics for children's performance in KTK tests are presented. The results showed that the highest average was achieved in the Backward Walking test, while the lowest average was achieved in Platform Shifting. Standard deviations show moderate distribution in most variables, implying normal variation in coordination skills in this age group. The total (sum of five tests) gives a general overview of the level of motor coordination.

TABLE 2. Statistics by gender: Average comparison and distribution for girls and boys on each test, useful for looking at gender trends.

index	F	F	F	F	F	F	M	M	M	M	M	M
	Bac kwa rd Wal king	Hoppin g L	Hoppin g R	Later al Jump s	Platfo rm Shif ti ng	Total	Backw ard Walkin g	Hopp ing L	Hoppin g R	Lat eral Jum ps	Platfo rm Shif ti ng	Total
25%	36.0	13.0	15.0	23.0	7.5	99.0	31.25	15.0	17.0	23.0	7.0	99.25
50%	43.0	18.0	18.0	27.0	9.0	117.0	39.0	18.0	20.5	25.5	9.0	112.0
75%	52.5	21.0	23.5	30.5	10.0	130.5	45.75	21.0	24.0	30.0	9.0	123.7
count	71.0	71.0	71.0	71.0	71.0	71.0	74.0	74.0	74.0	74.0	74.0	74.0
max	67.0	27.0	27.0	43.0	17.0	160.0	67.0	27.0	27.0	40.0	13.0	166.0
mean	42.5	17.0	18.0	26.6	8.6	112.9	38.0	17.9	19.68	25.7	8.4	109.7
min	14.0	6.0	7.0	12.0	5.0	59.0	15.0	7.0	7.0	11.0	5.0	59.0
std	12.7	5.2	5.3	5.8	1.9	22.9	11.4	4.8	4.8	5.9	1.6	23.3

This result represents the division by gender. Girls showed somewhat higher averages in Backward Walking and Lateral Jumps, while boys had higher values in Hopping (especially



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with the right foot) and Platform Shifting. However, the differences were not very large at the descriptive level, suggesting a rough distribution of coordination skills between the sexes.

TABLE 3. Normality tests: Displays Shapiro-Wilk p -values; helps to determine the use of parametric or non-parametric tests.

Variable	W	p-value	n
Backward walking	0.98	0.094	145.0
Hopping r	0.96	0.00032	145.0
Hopping l	0.96	0.00089	145.0
Lateral jumps	0.98	0.057	145.0
Platform shifting	0.93	0.091	145.0
Total	0.98	0.037	145.0

As shown in Table 3 (Shapiro-Wilk test), total motor coordination ($p = .037$), Hopping R ($p < .001$), and Hopping L ($p < .001$) deviated significantly from normality ($p < .05$). Conversely, Backward Walking ($p = .094$), Lateral Jumps ($p = .057$), and Platform Shifting ($p = .091$) showed a normal distribution ($p > .05$).

TABLE 4. Gender comparison: Summarizes the results of t -tests or Mann-Whitney U; shows where significant differences are found between boys and girls.

Variable	Test	Statistic	P-value	EffectType	EffectValue	n_male	n_female
Backward Walking	t-test (Welch)	-2.24	0.026	Cohen's d	-0.373	74	71
Hopping R	Mann-Whitney U	3083.0	0.039	r	0.149	74	71
Hopping L	Mann-Whitney U	2898.5	0.049	r	0.089	74	71
Lateral Jumps	t-test (Welch)	-1.01	0.314	Cohen's d	-0.167	74	71
Platform Shifting	Mann-Whitney U	2435.5	0.032	r	-0.062	74	71
Total	t-test (Welch)	-0.82	0.409	Cohen's d	-0.137	74	71



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It summarizes comparative analyses between boys and girls.

(1) Boys achieved significantly higher performance scores in Hopping R ($p = 0.039$) and Platform Shifting ($p = 0.032$).

(2) Conversely, girls performed significantly better in Backward Walking ($t = -2.24$, $p = 0.026$).

(3) No statistically significant gender differences were found in Lateral Jumps ($p = 0.314$), Hopping L ($p = 0.049$), or Total Score ($p = 0.409$).

(4) Effect sizes (Cohen's d and r) ranged from small to medium, indicating that gender disparities in motor coordination remain subtle at this developmental stage.

Tables 5 and 6 - Correlations: Give the Pearson and Spearman correlation matrices; show how related the sub-tests are to each other and to the total.

TABLE 5. Spearman Rank Correlation Matrix Across KTK Subtests and Total Score

Variable	Backward Walking	Hopping R	Hopping L	Lateral Jumps	Platform Shifting	Total
Backward Walking	1.0	0.37	0.41	0.48	0.31	0.85
Hopping R	0.37	1.0	0.82	0.40	0.30	0.72
Hopping L	0.41	0.82	1.0	0.43	0.33	0.75
Lateral Jumps	0.48	0.40	0.43	1.0	0.40	0.72
Platform Shifting	0.31	0.30	0.33	0.40	1.0	0.49
Total	0.85	0.72	0.75	0.72	0.49	1.0



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TABLE 6. Pearson Correlation Matrix Between KTK Subtests and Total Score

Variable	Backward Walking	Hopping R	Hopping L	Lateral Jumps	Platform Shifting	Total
Backward Walking	1.0	0.32	0.36	0.46	0.35	0.79
Hopping R	0.32	1.0	0.82	0.40	0.32	0.72
Hopping L	0.36	0.82	1.0	0.42	0.36	0.76
Lateral Jumps	0.46	0.40	0.42	1.0	0.42	0.71
Platform Shifting	0.35	0.32	0.36	0.42	1.0	0.51
Total	0.79	0.72	0.76	0.71	0.51	1.0

In Table 6, Most tests had strong and positive associations with each other ($r = 0.40-0.70$). The strongest connections were observed between Hopping L and Hopping R, as well as between Backward Walking and Lateral Jumps. The total correlates strongly with each sub-test, proving that the total index well represents overall coordination ability.

Relationship between results and sensory-perceptual skills:

Backward Walking requires spatial orientation and visual-vestibular integration. Good results here indicate good perceptual skills in balance control without direct views of the direction of movement. In relation to senso-perception: it is related to spatial orientation and vestibular control. R/L hopping (one-legged jumping), requires bilateral coordination, body perception in space, and the ability to control forces while landing. Sensory-perceptual connection: children with high scores usually have developed proprioception and good skills for controlling muscle strength. Lateral Jumps, tests the ability to change direction rhythmically and quickly.

Discussion

The primary objective of this study was to evaluate gross motor coordination in 8- to 9-year-old primary school children in Shkodra using the Körperkoordinationstest für Kinder (KTK), with specific focus on identifying sex-specific performance variations and sensorimotor profiles. Overall, the analyzed cohort demonstrated adequate baseline gross motor competence, though distinct sex-related differences emerged across individual subtests.



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A key finding of this investigation was observed in the Backward Walking subtest, where girls scored significantly higher than boys ($t = -2.24$, $p = .026$; 42.5 vs. 38.0 points). This variance indicates more refined dynamic balance control, postural stability, and backward spatial orientation among females in this age group. These observations agree with empirical data from Bardid et al. (2016), who noted that dynamic postural control and visual-proprioceptive integration undergo rapid refinement during middle childhood, with girls often demonstrating earlier developmental maturity in balance-dominated tasks.

Motor skill acquisition during early childhood does not occur in isolation; it interacts continuously with broader physical, cognitive, and somatic factors. Psychomotor interventions have been shown to positively influence early cognitive domains and functional movement efficiency (Cavieres et al., 2026). As children progress through primary school, coordinative efficiency and muscular output evolve alongside individual growth patterns and somatic maturity (Luna-Villouta et al., 2026). Sex and chronological age consistently modulate the interplay between coordination, strength, and movement speed (Ramos et al., 2022), while standardized field assessments remain essential for monitoring these motor trajectories (Velásquez et al., 2024).

In contrast to balance tasks, boys displayed a statistically significant advantage in Hopping Right ($p = .039$), whereas performance on Hopping Left showed no sex difference ($p = .419$). Boys also performed significantly better in the Platform Shifting subtest ($p = .032$). These localized differences point to higher lower-limb explosive power, unilateral motor unit recruitment, and faster body-transposition speed in boys at this stage. These trends mirror previous findings in pediatric movement science, where tasks requiring brief bursts of power and spatial reconfiguration tend to favor males (Li et al., 2023; Ribeiro et al., 2010).

Conversely, no significant differences were observed in Lateral Jumps ($p = .314$) or the total KTK score ($p = .409$). This indicates that continuous rhythmic coordination, motor planning, and global motor competence progress at comparable rates in both sexes between ages 8 and 9. As highlighted by Vandorpe et al. (2010), overall motor competence during middle childhood is driven primarily by age-dependent maturation and physical activity exposure rather than sex alone.



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Inter-subtest correlations revealed moderate to strong positive associations across all parameters ($r = 0.40-0.70$), supporting the framework that distinct sensorimotor components collectively underpin overall gross motor competence. Longitudinal evidence confirms that motor skill proficiency established during these formative years strongly influences long-term physical literacy and physical activity levels (Lima et al., 2017).

These findings provide practical insights for physical education curriculum design. Given that children in Shkodra show solid baseline coordination, integrating targeted balance, proprioceptive, and agility drills at least twice per week could further enhance motor skill acquisition (Gigirey-Vilar et al., 2026). Exposure to diverse movement patterns and multisport activities remains particularly effective for elevating KTK scores and functional movement quality (Mancini et al., 2025).

The mean KTK values in this Albanian cohort align with pediatric reference data from neighboring European countries, including Italy and Croatia (Iivonen et al., 2015; Novak et al., 2016). This similarity supports the utility of these data as preliminary reference values for regional screening, despite operational challenges sometimes reported in local movement research (Marta et al., 2026).

Certain limitations should be considered when interpreting these results. Morphological characteristics, such as Body Mass Index (BMI) and fat-free mass, were not measured, despite their known impact on motor coordination (Lima et al., 2017). Future research should incorporate anthropometric measures and longitudinal tracking to establish a more comprehensive model of child motor development in Albania.

Conclusions

This study demonstrates that 8- to 9-year-old primary school children in Shkodra possess consolidated gross motor coordination aligning with international normative references. Core functional attributes, including visual-spatial orientation and dynamic balance, are well established at this developmental stage. Sex-specific variations are task-dependent rather than indicative of overall motor disparity: boys demonstrate superior output in tasks demanding lower-limb explosive power and rapid body transposition (Hopping Right and



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Platform Shifting), whereas girls exhibit greater proficiency in dynamic balance control during backward locomotion (Backward Walking). Conversely, rhythmic coordination, continuous motor planning, and aggregate KTK scores remain comparable across sexes.

These results confirm the Körperkoordinationstest für Kinder (KTK) as a valid, reliable field instrument for assessing pediatric motor competence in Albania. From an applied perspective, physical education curricula in primary schools should incorporate structured sensorimotor exercises-specifically targeting balance, proprioception, and body awareness-at least twice weekly. Implementing standardized motor assessments and targeted instructor training can optimize early physical literacy, providing an evidence-based foundation for supporting active, healthy physical development in school-age children.

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