

Exploring the Relationship Between Motor Competence and Physical Performance in Preschool Children: A Cross-Sectional Study

Exploración de la relación entre la competencia motriz y el rendimiento físico en niños en edad preescolar: Un estudio transversal

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Abstract. Objectives: Motor competence (MC) and physical fitness are important factors for a healthy life over time. This study aimed to assess the association between motor competence and physical performance in children aged 4-6 years. Methods: One hundred thirty-nine children (78 boys and 61 girls) were recruited for the study from a preschool in Tekirdağ province, Turkey. Their motor competence was evaluated by the Körperkoordinationstest für Kinder (KTK+3) test battery combined with an alternating one-handed ball-catching and -throwing task on the first day of the study. On the second day of the study, the children underwent a series of performance tests, including the static and dynamic balance test, pro-agility test, and countermovement jump test. Results: Partial correlation analyses showed no association between motor competence and any performance test results. Fisher's r-to-z analysis test also indicated that gender did not differentiate the results in terms of the potential association between motor competence and performance test results. Conclusion: No significant association was found between motor competence and physical performance in children aged 4-6 years. Gender did not influence this relationship either. These findings suggest that further research with larger and more diverse samples is needed to better understand the link between motor competence and physical performance in early childhood.

Keywords: Motor competence, physical performance, children, preschool, gender.

Resumen. Objetivo: La competencia motriz (CM) y la aptitud física son factores importantes para una vida saludable a lo largo de la vida. El propósito del estudio fue evaluar la asociación entre la competencia motriz y el rendimiento físico en niños de 4 a 6 años. Métodos: Ciento treinta y nueve niños (78 niños y 61 niñas) de preescolar de la provincia de Tekirdağ, (Turquía) participaron en la investigación. Su competencia motriz se evaluó mediante la batería de pruebas Körperkoordinationstest für Kinder (KTK+3) combinada con una tarea alternativa de lanzamiento y recepción de pelotas con una mano el primer día del estudio. En el segundo día del estudio, los participantes realizaron una serie de pruebas de rendimiento, incluyendo la prueba de equilibrio Miniboard, la prueba de Pro agilidad y la prueba de salto con contramovimiento. Resultados: Los análisis de correlación parcial no mostraron asociación entre la competencia motriz y los resultados de las pruebas de rendimiento. La prueba de análisis r-to-z de Fisher también demostró que el género no tenía efecto significativo en los resultados en relación con la posible asociación entre la competencia motriz y el rendimiento físico. Conclusión: No se encontró asociación significativa entre la competencia motriz y el rendimiento físico en niños de 4 a 6 años. El género tampoco influyó en esta relación. Estos hallazgos sugieren que se necesitan más investigaciones con muestras más grandes y diversas para comprender mejor el vínculo entre la competencia motriz y el rendimiento físico en la primera infancia.

Palabras clave: Competencia motriz, rendimiento físico, niños, preescolar, género.

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Introduction

Early childhood is when a child's psychomotor, social, emotional, intellectual, and language development is shaped (TC Milli Eğitim Bakanlığı, 2011). Early childhood is also characterized by the rapid development of children's gross and fine motor skills (Hudson et al., 2020). This period is further characterized by essential processes in brain development and the opportunities to learn and practice motor skills by exploring and experiencing bodily movements through functional activities and play (Gottlieb, 2001; Piek et al., 2012). Also, physical and physiological components usually related to present and future health outcomes are essential during this period (Powel et al., 2011). The connection between motor competence and various health outcomes and leisure activities has been thoroughly documented in adolescence and adulthood (Herlitz et al., 2021). Basic locomotor, manipulative, and stability skills should be developed in the early childhood to gain motor control and competence to respond to various stimuli (Gallahue, 1989). However, a decrease in children's motor competence (MC) and physical fitness levels has been

reported in Western countries over the past few decades (Bardid et al., 2015).

Motor competence and physical fitness are important factors for promoting positive trajectories health trajectories over time (Utesch et al., 2019). The development of MC and physical fitness during childhood and adolescence is dependent upon and influenced by both biological (i.e., genetics, sex, and maturation) and environmental factors (e.g., gender roles, rearing style, stereotyping, experiences, opportunities to play, encouragement, demographics, and social factors) (Barnett et al., 2008; Morano et al., 2020; Thomas et al., 2005; Venetsanou et al., 2009), as well as their interactions (Lopes et al., 2010). Physical activity is also accepted as one of the most important factors affecting MC and physical fitness in children.

Increased physical activity provides more opportunities to promote neuromotor development, which promotes the development of fundamental motor skills (i.e., running, galloping, skipping, hopping, sliding, leaping, throwing, catching, bouncing, kicking, striking, rolling) (Stodden et al., 2008). However, lack of physical activity

constitutes a severe global health problem (Guthold et al., 2020). Motor competence has been positively correlated to participation in physical activity in preschool children (Cliff et al., 2009; Fisher et al., 2005; Williams et al., 2008). Moreover, an association between motor competence and physical fitness is reported among older children and adolescents (Gísladóttir et al., 2014). Stodden et al. (2008) suggested that children's physical activity might drive their development of motor skill competence. A study by Lopes et al. (2010) argued that one of the cornerstones of a physically active lifestyle is motor competence (MC). Robinson et al. (2015) reported that a positive relationship exists among MC, physical activity, and physical fitness level, including cardiorespiratory endurance and muscular strength/endurance, and an inverse relationship between weight status and MC from childhood into adolescence. Additionally, physically fit children are more likely to be physically active and continue developing their motor competence (Stodden et al., 2009).

Understanding the relationship between motor competence and physical fitness, especially in early childhood, may contribute to developing appropriate strategies to initiate health-related behaviors and promote an active lifestyle (Sigmundsson & Haga, 2016). Our study aimed to assess the relationship between motor competence and physical performance in children aged 4-6. The study hypothesized that a positive relationship exists between motor competence and physical performance in children.

Materials and methods

Participants

The study group comprises 139 students (78 boys and 61 girls) aged 4-6 studying in a public preschool. Among the criteria for inclusion of students in the study was that they must not have an orthopedic, cardiological, or neurological disease that would inhibit the movements to be performed in the measurements and tests. In addition, they were asked not to engage in strenuous physical activity before the measurements and not to use painkillers or sleeping tablets one day before the measurements. Application was made to the Scientific Research and Publication Ethics Committee of Tekirdağ Namık Kemal University for ethics committee approval, and the necessary approval for the research (Protocol No: 2022.214.11.15) was obtained. Furthermore, the application was made to the Tekirdağ Provincial Directorate of National Education for permission to conduct the research in primary schools. The necessary permission was obtained for the research with the approval of Tekirdağ Provincial Directorate of National Education and Tekirdağ Governorship (Letter of approval from Tekirdağ Provincial Directorate of National Education number: 63592556, date: 15.11.2022). In addition, a voluntary and parental consent form containing information about the research's purpose, objective, method, and permission was sent to students' families, and the students for whom permission was obtained were included in the study.

Procedure

On the first day of the tests and measurements, anthropometric measurements were performed: height and body weight measurements. Subsequently, the measurement protocols of the KTK3+ test battery were theoretically and practically explained and demonstrated in detail to the students by the researchers. The administration of the subtests of the KTK3+ test battery was made in the following order: jumping sideways, balancing backward, moving sideways, and hand-eye coordination. The participants were measured and tested in the same order by the same researchers. On the second day of the study, before conducting the tests, the study participants completed a 10-minute structured warm-up consisting of three phases: 5 minutes of activation exercises targeting major muscle groups, including activities such as light jogging, skipping, lateral running, backward running, and jumping jacks. This was followed by dynamic stretching exercises and, finally, by exercises of a higher level of specificity related to the preceding activity, such as static balance exercises, shuttle runs, and jumps. While testing, the participants were encouraged to do their best according to their abilities (Pacholek, 2023; Pacholek & Zemková, 2022), with a message tailored to their level of verbal comprehension, and intellectual and emotional maturity. All tests were administered in the school's multipurpose sports hall or gym during the time when students were studying.

Motor Competence Test

KTK3+ Test Battery

This study determined students' motor coordination levels and movement competencies by administering the Körperkoordinationstest für Kinder (KTK+3) test battery. The test is used to evaluate motor coordination in children and adolescents. The KTK3 (Kiphard & Schilling, 1974; Novak et al., 2017) was supplemented with a throwing and catching task (Platvoet et al., 2018) to assess hand-eye coordination. Moreover, this study revealed good test-retest reliability for all subtests: balancing backward (BB) 0.86, moving sideways (MS) 0.77, jumping sideways (JS) 0.88, and eye-hand coordination (EHC) 0.85. The average test administration time for each student is 15-20 minutes.

KTK3

The KTK3 is a measurable (quantitative) test tool with high validity and reliability to evaluate overall gross motor coordination (Kiphard & Schilling, 1974; Novak et al., 2017). The KTK3 consists of three test items that are frequently used on a global scale. The first test is sideways jumping, whereby participants have to jump on a wooden platform on both feet for 15 seconds. The resulting score is obtained from the total number of jumps made across two attempts. In the second test, participants must move sideways using two wooden platforms for 20 seconds. The total score is obtained by adding the number of times participants put one wooden platform down and the number

of times they step on the displaced wooden platform across two attempts. The third and final test of KTK3 is backward balancing, for which three attempts can be made, and is performed on three balance beams that narrow (from 6.0 cm to 4.5 cm to 3.0 cm) as the test progresses. The total number of steps is counted, and a maximum of 72 steps (or eight steps on each balance beam per attempt) can be taken.

Hand-Eye Coordination Test

In their study examining children aged 6 to 10 years, Platvoet et al. (2018) revealed that when supplemented with a throwing and catching task that assesses eye-hand coordination, the KTK3 covers those mentioned above three basic motor skill areas (i.e., locomotion, balance, and object control). Moreover, their studies revealed good test-retest reliability for all subtests: balancing backward (BB) 0.80, moving sideways (MS) 0.84, jumping sideways (JS) 0.95, and eye-hand coordination (EHC) 0.87 (Kiphard & Schilling, 1974; Novak et al., 2017). The EHC task used by Platvoet et al. (2018) requires the individual to throw a tennis ball against the wall with one hand and catch the ball with the other hand. It is a simple and objective test to assess ball control and predictive capacity.

Physical Performance Tests

Measurement of Balance Performance

Balance was assessed using a mobile platform with an interactive training tool (Sensbalance MiniBoard; Sensamove®, Utrecht, The Netherlands). The device used is based on innovative, non-invasive technology that enables real-time data recording and offers the possibility of storing data files, Excel, and graphic files. In addition to examining static and dynamic balance and ankle joint mobility, the above-mentioned measuring apparatus also allows us to test proprioceptive balance. The tests were administered to the participants twice. A rest interval of 1-2 minutes was given between tests. The best score was recorded as balance performance (Liviu et al., 2018). Unfortunately, there is no data on the validity and reliability of the device.

Pro-Agility Test

The test track was prepared by placing markers 5 yards (4.57m) to the left and right of the starting line. A photocell gate was placed on the starting line. In this way, repeated transition times could be obtained. Before the practice began, the athlete took his/her place on the starting line. When he/she was ready, he/she first touched the marker on the right, then the marker on the left, and finally crossed the starting line to end the test (Bayraktar, 2013). The measurement was made twice. A 3-minute rest interval was given between measurements, and the measurement with the lowest time from the two measurements was used for the statistical analysis. Mayhew et al. (2010) reported high reliability values for the Pro-Agility test ($r = 0.80$).

Countermovement Jump Test

Jump performance was measured using a Myotest accelerometer system (Myotest® Performance Measurement system, Sion, Switzerland). The device was attached vertically in the middle of the waist by fastening it on a belt, and all subjects were informed that they should avoid any involuntary movement in the vertical plane that could affect the jump height during jumps. The Myotest device has been proven to be valid and reliable for measuring vertical jump performance ($ICC = 0.96$) (Casartelli et al., 2010). CMJ had the great reliability ($\alpha = 0.98$). Also, CMJ had great average intertrial correlation (AVR) and IC (respectively, 0.94; 0.98) (Markovic et al., 2004). During the test, subjects were urged to jump as high as possible. The test was administered twice, with 30-60 seconds rest between applications, and the highest jump measurement from the two tests was used for the statistical analysis.

Statistical Analysis

Statistical analysis of the data obtained in the study was made using the SPSS 18.0 program. The correlation between all samples to which the test was applied was examined, and then the internal consistency and reliability of the samples were calculated using Cronbach Alpha reliability coefficients. In the data analysis, descriptive statistics (mean, standard deviation, frequency, and percentage values) were used to describe the study group's characteristics and were expressed using tables. Skewness and kurtosis values were examined to determine whether the research data were normally distributed. Studies have revealed that skewness and kurtosis values between -1.5 and +1.5 show that data are normally distributed, while values outside these measurements show that data are not normally distributed (Tabachnick, 2001). A total test score was calculated to express participants' overall performance on the four physical performance measures. Test item scores were converted from the mean of the entire sample to a standardized score (z-scores). Higher z-scores indicated better performance on the tasks. The correlation between binary variables was evaluated using partial correlation analysis by controlling some variables in the study. In addition, the correlation between variables was determined using Pearson product-moment correlation analysis. Fisher's r-to-z analysis was used to determine how the correlations between variables differed in terms of gender. The significance value was set at $p < 0.05$.

Results

Children's descriptive characteristics are presented in Table 1. Values for children's motor competence and physical performance are provided in Table 2. The results of the partial correlation analysis between total motor competence and physical performance are presented in Table 3. The association between total motor competence and physical performance in terms of gender is shown in Table 4.

Table 1.

Descriptive data regarding the age and anthropometric characteristics of the participants, as well as the frequencies and percentages by gender

Variables	Min.	Max.	Mean	Sd
Age (years)	4.91	6.47	5.75	0.29
Height (cm)	101.00	127.00	113.84	4.89
Body mass (kg)	13.95	33.65	20.98	3.73
BMI (kg/m ²)	10.69	22.77	16.15	1.94
Gender	<i>f</i>	%		
Boy	78	56.1		
Girl	61	43.9		
Total	139	100.0		

BMI: Body Mass Index; Min: Minimum; Max: Maximum; Sd: Standard deviation; *f*: frequency

Table 2.

Descriptive data regarding the participants' motor competence and physical performance elements

Variables	Mean	Sd
Physical performance		
Agility (sec)	9.47	0.92
Vertical Jump (cm)	19.21	3.61
Static balance (%)	77.12	11.92
Dynamic balance (%)	68.30	15.00
Motor competence		
KTK _{balance}	23.33	9.83
KTK _{jumping}	26.76	7.33
KTK _{moving}	25.63	5.35
KTK _{catching}	4.15	5.32

Sd: Standard deviation

Table 3.

Partial correlation results between participants' total physical performance and motor competence elements

	<i>r</i>	<i>p</i>
KTK _{balance}	<i>r</i>	0.046
	<i>p</i>	0.597
KTK _{jumping}	<i>r</i>	0.071
	<i>p</i>	0.409
KTK _{moving}	<i>r</i>	-0.070
	<i>p</i>	0.417
KTK _{catching}	<i>r</i>	0.064
	<i>p</i>	0.461

Control variables: Height and body mass

Participants' height and body weight were assessed as control variables. According to the results of the partial correlation analysis, no significant relationship was found between the participants' physical performances and any parameter representing motor competence ($p > 0.05$) (Table 3).

Table 4.

The data on the relationship between participants' total physical performance and motor competence in terms of the gender variable

	<i>r</i>	<i>p</i>
Boys	KTK _{balance}	0.087
		0.451
	KTK _{jumping}	0.234*
		0.039
	KTK _{moving}	0.064
		0.576
Girls	KTK _{catching}	0.092
		0.425
	KTK _{balance}	0.054
		0.678
	KTK _{jumping}	-0.048
		0.712
Girls	KTK _{moving}	-0.129
		0.322
	KTK _{catching}	0.038
		0.771

$p < 0.05^*$

A weak positive correlation was determined between

male participants' physical performances and their KTK jumping sideways performances ($r = 0.234$; $p < 0.05$). In this regard, according to the results of Fisher's *r*-to-*z* analysis, which tested whether there was a significant difference between the physical performance-KTK jumping sideways correlation found for girls and the level of correlation found for boys since the calculated difference value was lower than the critical *z* value indicating the limit of significance ($1.63 < 1.96$), no significant difference was found between the two groups in terms of correlation level ($p > 0.05$). Moreover, no significant relationship was found between physical performance and the other KTK parameters in either girls or boys ($p > 0.05$) (Table 4).

Discussion

This study assessed the relationship between motor competence and physical performance in children aged 4-6 years. The study's main finding is that partial correlation analysis revealed no significant relationship between the participants' physical performance and any parameter representing motor competence in preschool children. The study also hypothesized a positive relationship between motor competence and physical performance in preschool children. However, the study's hypothesis was not confirmed based on the main finding.

Differing from the results of our study, some researchers have reported positive correlations between motor competence and children's physical activity or physical fitness levels (Cliff et al., 2009; Fisher et al., 2005; Holfelder & Schott, 2014; Lopes et al., 2010; Pacholek, 2023; Williams et al., 2008). However, similar to our study, Barnett et al. (2016) did not find physical activity to be a consistent positive predictor of motor competence. Haga (2008) reported a strong and significant correlation ($r = -0.59$) between motor competence and physical fitness in children aged 9-10. Gísladóttir et al. (2014) also reported a significant but weak relationship ($r = 0.25$) between motor competence and physical fitness for the whole sample. More specifically, the correlation between these two variables was significant for girls ($r = 0.35$) but not for boys ($r = 0.25$) in adolescents aged 15 to 16. Based on the abovementioned results, Sigmundsson and Haga (2016) argued that the association between motor competence (MC) and physical activity decreases as age increases. Sigmundsson and Haga (2008) paraphrased that age may be important in elucidating the relationship between MC and physical fitness. Additionally, physical activity has a good impact on several physical fitness components, and motor competence (Stodden et al., 2008). The level of physical effort required to achieve locomotor and object control abilities can be used to explain the moderate link seen between motor competence and musculoskeletal fitness (Handelsman, 2007).

Barnett et al. (2016) reported that the most examined correlates of gross motor competency were biological and demographic factors. Age was positively correlated, while sex showed that boys were more skilled than girls in object

control and motor coordination. Adiposity was negatively correlated with motor coordination, stability, and skill composite. In terms of age, the results of the study by Haga (2008) are inconsistent with the results of the study by Barnett et al. (2016). Haga (2008) argued that gross motor competency correlates more strongly with physical fitness in childhood compared to adolescence.

When we evaluated the association between MC and physical performance in terms of gender, we did not find any significant association. We speculated that this result might be influenced by the age of our participants, who had an average age of 5.75 ± 0.29 years. This situation can be explained by referencing the study conducted in 2017 by Handelsman (2017), who reported that gender differences in athletic performance start to emerge around the age of 12-13 years and reach an adult plateau in the late teenage years. However, Lopes et al. (2023) suggest that athletics may have played a crucial role in the development of MC in children, with a seemingly greater impact on girls than on boys. This timing and progression closely parallel the increase in circulating testosterone levels in boys during puberty.

The socioeconomic background of the children recruited for the current study might influence the results obtained. Barnett et al. (2016) reported that a higher socioeconomic background is a consistent correlate for certain aspects of motor competence (MC). De Cos et al. (2019) also concluded that a higher level of motor competence could positively influence the psycho-social aspects studied. However, it is important to note that we did not assess the socioeconomic background of the children recruited for the present study. This could be a limitation of the study. Recruiting children from a single center is another limitation of the study, and it may restrict the generalizability of the results. According to the school schedule, we had to conduct all performance tests on two separate days. Fatigue could have affected the results of the performance tests.

Conclusion

The current findings indicate that there is no association between MC and physical performance in children aged 4-6 years. Gender does not emerge as a predictor for improved MC in childhood either. These results may be explained by the age of the children recruited for the study, as some authors (Haga, 2008; Sacko et al., 2018) suggested that gender differences in athletic performance emerge around the age of 12-13 years. However, replicating this study with a larger sample of children entering puberty, drawn from multiple centers, might yield different results and help clarify the relationship between MC and physical performance. Additionally, we recommend that, if feasible, MC evaluations and physical performance tests should be conducted with sufficient rest time between them.

Practical applications

The lack of direct association between motor competence

and physical performance in children aged 4 to 6 emphasizes the importance of considering age and socioeconomic background factors when designing interventions. More research is needed to explore the relationship between motor competence and physical performance in different age groups and demographic backgrounds. From a methodological point of view, controlling factors such as fatigue during performance testing is necessary.

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