

## Exploration of Children's Motor Skills with Stunting Vs. Non-Stunting

### Exploración de las habilidades motoras de los niños con retraso del crecimiento vs. Sin retraso del crecimiento

Nuridin Widya Pranoto\*, Varhatun Fauziah\*, Arif Fadli Muchlis\*, Anton Komaini\*, Rayendra Rayendra\*, Nugroho Susanto\* Gema Fitriady\*\*, Hendra Setyawan\*\*\*, Ratko Pavlovic\*\*\*\*, Alexandre Sibomana\*\*\*\*\*, Japhet Ndayisenga\*\*\*\*\*

\*Universitas Negeri Padang (Indonesia), \*\* Universitas Negeri Malang (Indonesia), \*\*\*Universitas Negeri Yogyakarta (Indonesia), \*\*\*\* University of East Sarajevo (Bosnia and Herzegovina), \*\*\*\*\* University of Burundi in Institute (Burundi)

**Abstract.** Background: Stunting is a growth problem that occurs in children due to chronic nutrition deficiency over a long period of time. This health problem often occurs in society and is very worrying. Unfortunately, its impact on children's development is not yet fully understood. Motor skills are often associated with the children's nutritional status. These skills are important for children as the basis for their ability to move when carrying out activities. This study aimed to evaluate differences in the motor skills of children diagnosed with stunting and non-stunting. Method: This research used a comparative approach. The sample consisted of 48 children with criteria aged 3 to 5 years. These children were divided into the stunting-diagnosed group (N=24) and the non-stunting group (N=24). Children's motor skills were measured using the TGMD-2 (Test of Gross Motor Development-2) motor skills test. The test has been tested for validity and reliability before being distributed to the participants. The Shapiro-Wilkxon test was used to check normal data distribution. Results & Discussion: The study showed a significant difference between children diagnosed with stunting and non-stunting children by comparison ( $P < 0.05$ ). Children diagnosed with stunting were reported to have lower motor skills on average gross Motor Quotient  $\bar{x} \pm 7$ . This value is below average category, while non-stunting children have Gross Motor Quotient  $\bar{x} \pm 11.125$ , which is beyond the average category. In male stunting children, the highest performance was in the kick movement skill with a value of  $\pm 4.25$ , while the lowest performance was in the gallop skill with a value of  $\pm 2.00$ . For girls with stunting, the highest performance was in the object control skill, striking a stationary ball with a value of  $\pm 3.53$ . On the other hand, the lowest performance was in the gallop skill, with a value of  $\pm 1.32$ . In terms of motor skills, normal boys performed better than girls in jumping, hopping, and sliding ( $P < 0.05$ ). For non-stunting boys, the highest performance was in hop movement skills with a value of  $\pm 7.05$ , while the lowest was in stationary dribble skills with a value of  $\pm 4.77$ . Non-stunting girls resembled the boys as the highest performance was in the locomotive hop skill with a value of  $\pm 7.67$ , while the lowest performance was in the underhand roll skill with a value of  $\pm 5.11$ . In terms of motor skills, non-stunting children performed better than stunting boys and girls ( $P < 0.05$ ). Conclusion: There were significant differences in motor skills between the two groups. Children diagnosed with stunting have lower motor skills compared to non-stunting children. These results provide a better understanding of the impact of stunting on children's motor development. This research also emphasizes the importance of early intervention to improve the motor skills of children diagnosed with stunting. These findings have the potential for efforts to prevent and treat stunting in children and promote the welfare of children's overall development.

**Keywords:** Locomotor skills; Object control skills; Basic motor skills; Children; Development; Nutritional status.

**Abstracto.** Antecedentes: El retraso del crecimiento es un problema de crecimiento que ocurre en los niños debido a una deficiencia nutricional crónica durante un largo período de tiempo. Este problema de salud ocurre frecuentemente en la sociedad y es muy preocupante. Desafortunadamente, aún no se comprende completamente su impacto en el desarrollo de los niños. Las habilidades motoras suelen estar asociadas con el estado nutricional de los niños. Estas habilidades son importantes para los niños como base de su capacidad de moverse al realizar actividades. Este estudio tuvo como objetivo evaluar las diferencias en las habilidades motoras de niños diagnosticados con retraso del crecimiento y sin retraso del crecimiento. Método: Esta investigación utilizó un enfoque comparativo. La muestra estuvo compuesta por 48 niños con criterios de edad de 3 a 5 años. Estos niños se dividieron en el grupo con diagnóstico de retraso del crecimiento (N=24) y el grupo sin retraso del crecimiento (N=24). Las habilidades motoras de los niños se midieron mediante la prueba de habilidades motoras TGMD-2 (Test of Gross Motor Development-2). Se ha probado la validez y confiabilidad de la prueba antes de distribuirla a los participantes. Se utilizó la prueba de Shapiro-Wilkxon para comprobar la distribución normal de los datos. Resultados y discusión: En comparación, el estudio mostró una diferencia significativa entre los niños diagnosticados con retraso del crecimiento y los niños sin retraso del crecimiento ( $P < 0,05$ ). Se informó que los niños diagnosticados con retraso en el crecimiento tenían habilidades motoras más bajas en promedio en el cociente motor bruto  $\bar{x} \pm 7$ . Este valor está por debajo del promedio de la categoría, mientras que los niños sin retraso en el crecimiento tienen un cociente de motricidad gruesa  $\bar{x} \pm 11.125$ , que está por encima de la categoría promedio. En los niños varones con retraso del crecimiento, el mayor rendimiento fue en la habilidad de movimiento de patada con un valor de  $\pm 4,25$ , mientras que el menor rendimiento fue en la habilidad de galope con un valor de  $\pm 2,00$ . Para las niñas con retraso en el crecimiento, el rendimiento más alto fue en la habilidad de control de objetos, golpeando una pelota estacionaria con un valor de  $\pm 3,53$ . Por otro lado, el menor rendimiento se presentó en la habilidad de galope, con un valor de  $\pm 1,32$ . En términos de habilidades motoras, los niños normales obtuvieron mejores resultados que las niñas en saltos, brincos y deslizamientos ( $P < 0,05$ ). Para los niños sin retraso en el crecimiento, el rendimiento más alto fue en habilidades de movimiento de salto con un valor de  $\pm 7,05$ , mientras que el más bajo fue en habilidades de regate estacionario con un valor de  $\pm 4,77$ . Las niñas sin retraso del crecimiento se parecían a los niños, ya que el rendimiento más alto fue en la habilidad de salto locomotor con un valor de  $\pm 7,67$ , mientras que el rendimiento más bajo fue en la habilidad de rodar hacia abajo con un valor de  $\pm 5,11$ . En términos de habilidades motoras, los niños sin retraso del crecimiento obtuvieron mejores resultados que los niños y niñas con retraso del crecimiento ( $P < 0,05$ ). Conclusión: Hubo diferencias significativas en las habilidades motoras entre los dos grupos. Los niños diagnosticados con retraso del crecimiento tienen habilidades motoras más bajas en comparación con los niños sin retraso del crecimiento. Estos resultados proporcionan una mejor comprensión del impacto del retraso del crecimiento en el desarrollo motor de los niños. Esta investigación también enfatiza la importancia de la intervención temprana para mejorar las habilidades motoras de los niños diagnosticados con retraso en el crecimiento. Estos hallazgos tienen el potencial de impulsar esfuerzos para prevenir y tratar el retraso del crecimiento en los niños y promover el bienestar del desarrollo general de los niños.

**Palabras clave:** Habilidades locomotoras; Habilidades de control de objetos; Habilidades motoras básicas; Niños; Desarrollo; Estados nutricionales.

Fecha recepción: 29-11-23. Fecha de aceptación: 06-02-24

Nuridin Widya Pranoto  
nuridin@fik.unp.ac.id

## Introduction

The last decade has seen an unprecedented increase in attention to the problem of malnutrition. This is reflected by various nutrition initiatives around the world, such as setting global goals for nutrition and publishing high-level scientific papers that emphasize the urgency of the issue.

Among children under five years of age, an estimated 22 percent will be affected by stunting in 2020 in West Africa, Southeast Asia, Europe, and Central Asia (Liu, Liang, & Chen, 2024; Mudadu Silva et al., 2023a). Around 149 million preschool children aged up to five years, mostly from low- and middle-income countries, are stunted (Akseer et al., 2022; Taib & Ismail, 2021).

Therefore, reducing stunting rates in children has become a key focus, as reflected in the World Health Assembly's first global nutrition targets. This assembly aims to reduce the number of children under five who are stunted by 40% by 2025 (Prendergast & Humphrey, 2014a; Rukiko, Mwakalobo, & Mmasa, 2023). This target can be achieved by carefully observing the children's development and growth as early as possible. One skill often associated with children's overall development and long-term physical literacy is fundamental movement skills (FMS). However, FMS is not acquired naturally but needs to be trained. (Bossavit & Arnedillo-Sánchez, 2023; Sulistiyowati et al., 2022; D. Zhang et al., 2023)

Acquiring motor skills is very important for children's development because it is related to cognitive development. However, access to early detection of motor developmental delays is limited (de Onis & Branca, 2016a; Faber, van den Bos, Houwen, Schoemaker, & Rosenblum, 2022).

Fundamental movement skills (FMS) have a crucial role as a foundation that can be observed and used to develop further skills needed in various types of physical activity, both recreational and competitive. Identifying the status of children's motor skills earlier plays an important role in their development throughout childhood and life because it will shape their overall movement patterns (Webster, Martin, & Staiano, 2019).

Children, especially those aged 2-7 years, acquire basic skills through reflexive and basic exercises and are able to develop further skills in certain stages of sport (Gandotra et al., 2020; Jones, Innerd, Giles, & Azevedo, 2020). The ability to fully master FMS, especially in terms of object control, is critical to understanding more complex sporting patterns and increasing the chances of success in a wide variety of sports in the future (Van Biesen, Van Damme, Pineda, & Burns, 2022). Conversely, if impairments in basic movement skills are not identified at an early age, children may experience impairments in motor skills throughout their lives (McKenzie et al., 2002). Therefore, attention to FMS development at an early age is essential to ensure children have a strong foundation in motor skills that will help them participate in a variety of physical activities and sports throughout their lives.

Stunting can affect children's motor development, especially in children aged 3-5 years, a critical period in motor development. Children who experience stunting tend to have physical weaknesses, including muscle weakness, poor coordination, and delays in gross and fine motor development. Gross motor development includes body movements involving large muscles, such as walking, running, and jumping. Children diagnosed with stunting tend to experience delays in gross motor development, so there may be a delay in their ability to walk, run and play with their peers. It is driven by common factors through the process of accumulating nutritional deficits and effectively placing children most at risk of short-term death (Thurstans et al., 2022).

The lack of nutrition status in children can lead to several health problems. For example, it can result in low cognitive and motor skills in children, which impacts their growth as adults. This situation can be seen regarding the cognitive and motor levels of stunted children (Mastuti & Indahwati, 2021a). Particularly, motor disorders affect children's activity and participation levels and lead to low levels of physical activity, fitness and health into adulthood. While severe motor deficits are usually diagnosed before two years of age, mild motor deficits may not become apparent until children are in preschool and elementary school settings, where they face increasingly complex tasks and are compared with their peers. A 2015 study published in the *Journal of Frontiers in Physiology* found that poor nutritional conditions in pregnant women can affect children's growth, including stunting. The study also found that adequate nutritional intake in pregnant women can help reduce the risk of stunting (Rahman et al., 2018)

Although many scholars agree on the negative consequences caused by stunting, research on fundamental movement skills (FMS) proficiency in preschool children in low- and middle-income countries is limited. In fact, children from economically disadvantaged backgrounds may experience delays in developing their motor skills, which can have a negative impact on their health (Aye, Oo, Khin, Kuramoto-Ahuja, & Maruyama, 2017). In addition, findings from research on ethnic differences in sports skills show that ethnic groups with higher physical health risks tend to have lower sports skills. The complex relationship between ethnicity and socioeconomic status may amplify the risk for health problems and delayed sports abilities in children. Therefore, it is important to investigate this concept as well.

In the context of low- and middle-income countries, attention to motor skill development in preschool children from economically disadvantaged backgrounds is important to improve the well-being and health of these children (O'Brien, Belton, & Issartel, 2016). Additionally, a better understanding of the role of ethnicity and socioeconomic status in sports skills may help design more effective interventions to address health problems and delayed sports abilities in vulnerable children.

## Method

### Design

This research involved participants from two different sampling groups, obtained using a descriptive cross-sectional study sampling method. The participants were children aged 3-5, selected based on their stunting and non-stunting nutritional statuses. Data were collected by testing children's locomotor and object control with the TGMD-2 test. TGMD-2 measures 12 basic movement skills, divided into two subtests: locomotor and object control. The movement consists of run, gallop, hop, leap, horizontal jump, slide, stationary dribble, catch, kick, overhand throw, and underhand roll.

### Participant

This research recruited 48 preschool children within the various age ranges. The mean age of the participants was  $\pm 4.98$  years old. The children were divided based on their nutritional status, namely children diagnosed with stunting and normal children. The group of stunted children consisted of 24 children (12 girls and 12 boys). The stunting condition was determined by looking at the height, which was shorter compared to other children at this age. The criteria were classified based on the standard deviation (SD) value of the child's average height, which should be appropriate for his age, using a standard measure called the Z-score. Meanwhile, the normal child group consisted of 24 children (12 girls and 12 boys) who lived in Nagari Sako Selatan, Sungai Pagu District, South Solok Regency. This district ranked 3rd with the highest stunting status in West Sumatra, with a figure of 31.7.

### Procedure

Data was collected from September to October 2023. Information regarding each child's age, weight, and height was obtained twofold by gathering data from the Integrated Healthcare Center (Posyandu) and testing the children again directly. After that, the fundamental motor skills (FMS) were measured using the Gross Motor Skills Development Test (TGMD-2), validated for the Indonesian population. As the research involved human participants, it has requested and received approval from Padang State University. In addition, children who served as the subject of this research have been given the consent of their parents.

TGMD-2 measures 12 basic movement skills, divided into two subtests: locomotor and object control. The movement forms consist of run, gallop, hop, leap, horizontal jump, slide, stationary dribble, catch, kick, overhand throw, and underhand roll. The researchers were trained and obtained test qualification permits from Padang State University of Sports Science, the TGMD-2 testing authority. Each test group consisted of two children, two testers, and one photographer. Subjects repeated the test twice after observing a demonstration of the examiner's actions. The scores obtained from the different skills were added together to obtain a locomotor skills score (6 skills, with a

maximum score of 46) and an object control skills score (6 skills, with a maximum score of 46). The sum constituted the total FMS score (with a maximum possible score of 92). For example, when performing running skills, four points of performance criteria were applied.

In the evaluation of running skills, four performance criteria were considered. First, the arms were moved opposite the legs with the elbows bent. Second, there was a short period where both feet did not touch the ground. After that, the placement of the feet was narrowed so that they landed on the heel or toes. Finally, the legs without support were bent about 90 degrees, so the feet were close to the buttocks. For each performance criterion that was carried out correctly, a score of 1 was given. Meanwhile, if the performance criteria were not met, a score of 0 was given. The maximum score that could be obtained for running skills was 8, with the evaluation being repeated twice. A maximum of 4 points could be obtained for each evaluation time. In this research, mastery was defined as the correct performance of all criteria in two trials (e.g., 8 for running or 2 for one aspect of performance). Near mastery was defined as the correct performance of all but one performance criterion in two trials or a score of 1 for one performance aspect. Meanwhile, poor mastery was defined as incorrect performance/absence of more than one performance criterion in two trials or a score of 0 for one performance aspect.

### Statistical Analysis

FMS data were analyzed using SPSS version 23.0 for Windows. The software calculated descriptive statistics for mastery level, locomotor skills, and object control. Data are presented as mean  $\pm$  SD. Bivariate correlation analysis was employed to evaluate the relationship between BMI and raw skill scores. Further, the Pearson correlation coefficient ( $r$ ) was used to determine the correlation between children's nutritional status and the impact on their motor skills. For variables with interaction effects, simple effects analysis was used.

This research also compared group differences. In so doing, the main effect analysis was used. Statistical significance was set at  $P < 0.05$ . Bonferroni adjusted alpha was calculated at  $0.017 (p/3)$  to control for Type I error.

### Result

This study involved 24 children diagnosed with stunting. The mean age of boys ( $N = 12$ ) was 4.03 years old, while the mean age of girls ( $N = 12$ ) was 4.19. Further, children with normal nutritional status were slightly older where boys ( $N = 12$ ) were 5.91, and girls ( $N = 12$ ) were 5.82. Participant information is shown in Table 1.

The table above classifies participants based on their nutritional categories. The classification was based on the children's height, weight, and BMI. For example, the "stunting" category had an average height of 92.9 cm, an average weight of 12.00 kg, and an average BMI value of 13.92 (with their respective standard deviations). Girls in

this group had an average height of 93.6 cm, an average weight of 14.53 kg, and an average BMI of 16.56 (with respective standard deviations).

Meanwhile, in the "normal" category, the participants showed higher measures. For example, boys in this group had an average height of 103.1 cm, an average weight of 17.29 kg, and an average BMI of 16.26 (with respective standard deviations). Further, girls had an average height of 102.4 cm, an average weight of 16.06 kg, and an average BMI of 15.32 (with respective standard deviations).

Table 1. Participant descriptions were divided by nutritional status, age, and gender (average $\pm$ SD)

Category	Gender	N	Age	Height(cm)	Berat(Kg)	BMI
Stunting	man	12	4,03	92,9	12,00	13,92
	woman	12	4,19	93,6	14,53	16,56
Normal	man	12	5,91	103,1	17,29	16,26
	woman	12	5,82	102,4	16,06	15,32

Table 2.

Description Differences in skills of stunted and non-stunted children by sex with TGMD2

Skills	stunting		Normal		Average	P
	lk	Pr	lk	Pr		
Run	3,92	3,83	7,08	7,58	5,27	0,0020
Gallop	2,00	1,08	6,58	7,5	4,09	0,0020
Hop	3,08	3,75	7,75	7,75	5,29	0,0020
Leap	3,58	2,75	5,5	5,00	4,02	0,0020
Horizontal jump	3,33	3,33	5,91	5,75	4,51	0,0020
Slide	3,17	2,66	5,66	5,58	4,07	0,0020
Striking a stationary ball	3,92	3,5	6,33	6,41	4,91	0,0020
Stationary dribble	2,25	2,58	5,41	5,75	3,79	0,0020
Battle	3,25	3,08	5,41	5,5	4,21	0,0020
Kick	4,25	2,75	6	5,58	4,50	0,0020
Over hand throw	3,25	3	5,66	5,91	4,29	0,0020
Under hand Roll	3,00	2,58	5,16	5,25	3,86	0,0020

Table 2 provides a comparative description of motor skills between stunting and non-stunting children. The comparison is made following gender, using the Movement Perception Skills Test (TGMD2). Each motor skill average value was measured for both groups and described by gender.

As shown in Table 2, children with stunting have a lower average score than normal children in each type of skill. The P-value recorded in column 'P' indicates the statistical significance of this comparison. A low P value indicates a significant difference between the two groups in certain aspects of motor skills. For example, on the skill "run," boys with stunting had an average score of 3.92, while normal boys had an average score of 7.08. This difference was significant, with a P value of 0.0020, indicating a real difference in running skills between the two groups.

There are six locomotor skills (run, gallop, hop, leap, horizontal jump, slide) and six object control skills (striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll). Among these, the highest percentage of mastery was hopping ( $\pm 5.29$ ) and striking a stationary ball ( $\pm 4.91$ ). Meanwhile, the lowest percentages were leap ( $\pm 4.02$ ) and stationary dribble ( $\pm 3.79$ ). These occurred in both categories. Further analysis of this study focused on the specific problem where the highest percentage of possession in four running parameters was the second point (95%), "a brief period in which both feet do not touch

the ground." The highest percentage of mastery in the four slide aspects was given to "slide to the right continuously four times" and "slide to the left continuously four times," namely 78% and 79%, respectively. Meanwhile, the percentage rate of poor mastery of the 3-point gallop skill was always low: the child's hands were positioned in front of the body with bent elbows (25%), the arms were extended to grab the ball as it came (26%), and the ball was caught with the bare hands (22%). In TH's five-point shot, the highest percentage of bad possessions went to "this ball sent it straight forward," as 33% of kids missed the ball completely.

This research also analyzed the t-test results to examine the influence of nutritional status (stunting/normal) on individual motor skills. Scores are summarized in Table 3. There were significant differences in FMS or OC detected between stunted and normal children. In addition, significant differences were found in LM between girls and boys.

Table 3.

Tests of Normality Kolmogorov-Smirnov

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
normal male motor	.246	9	.125	.914	9	.348
motor stunting male	.200	9	.200*	.911	9	.324
motor women women	.330	9	.005	.819	9	.034
motor stunting for women	.317	9	.010	.815	9	.030

The results of the Kolmogorov-Smirnov test show statistical and significance values (Sig.) for each group, while the results of the Shapiro-Wilk test provide statistics and significance, which can provide a further picture of the normality of the data distribution. In general, if the significance value (Sig.) is greater than 0.05, it can be considered that the data distribution is not significantly different from the normal distribution. Conversely, a significance value smaller than 0.05 indicates evidence that the data distribution is not normal.

Table 3 indicates that the "normal male motor skills" group does not have significantly different data distribution, both according to the Kolmogorov-Smirnov and Shapiro-Wilk tests. The "male stunting motor" group showed a value less than 0.05 in the Kolmogorov-Smirnov test, indicating a distribution that was significantly different from the normal distribution. Although the results of the Shapiro-Wilk test did not provide the same significance, the "female normal motor" group showed that the data distribution was significantly different from the normal distribution according to both test methods. The "female motor stunting" group showed similar results, where the data distribution was significantly different from the normal distribution according to both tests. However, due to the minimal number of participants, the above data is not consistently normal. Therefore, non-parametric statistical analysis was employed using the Wilcoxon rank test, as illustrated in Table 4. Based on the statistical tests, the motoric values of stunting children (boys and girls) were smaller than those of normal ones (boys and girls). Girls were better than boys in several movements, like jumping ( $P < 0.05$ ), skipping

( $P < 0.05$ ), and sliding ( $P < 0.05$ ). Due to significant differences between both boys and girls in certain FMS skills, to exclude the influence of gender, boys and girls were studied separately when studying the influence of environmental and ethnic differences on FMS. Meanwhile, when comparing the raw scores of certain skills, six locomotor skills (run, gallop, hop, leap, horizontal jump, and slide) and six object control skills (striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll) showed significant differences between the stunting groups and normal. After adjusting the significance level using the Bonferroni method, it was found that six skills (run, gallop, hop, leap, horizontal jump, slide) with statistically significant differences were found in the stunting and normal groups.

Meanwhile, in the object control skills test, no significant difference was found between children. Likewise, in normal children, no significant differences were found in the control object test. In the implementation of the locomotor test, a statistically significant difference occurred between the stunting-diagnosed group, which got the highest gap in gallop skills, and the normal who got the highest score in this skill with a ratio of 4.55. In contrast, the test that had a fairly low comparison was the locomotor test in the skills test, with a comparison score of 2.03.

Table 4.  
Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
motor stunting male - motor normal male	Negative Ranks	12a	6.50	78.00
	Positive Ranks	0b	.00	.00
	Ties	0c		
	Total	12		
motor stunting women - motor women women	Negative Ranks	12d	6.50	78.00
	Positive Ranks	0e	.00	.00
	Ties	0f		
	Total	12		

Information:

- a. motor stunting of men < motor of normal men
- b. motor stunting of men > motor of normal men
- c. motor stunting male = motor normal male
- d. motor stunting of women < motor of women women
- e. motor stunting for women > motor for women women
- f. motor stunting female = motor female female

### Differences in nutritional status (stunting/normal) in FMS

In comparing 2 groups with different nutritional statuses, there were significant differences between the stunting and normal groups in locomotor scores and control objects. Analysis showed that stunted children had a significantly lower sum of LM and OC scores than normal children (all  $P < 0.05$ ). The Wilcoxon was then used to adjust the significance level of the paired tests. Differences in locomotor and control object scores between stunting and normal groups (all adjusted  $P < 0.05$ ).

Before carrying out inferential statistical tests to determine the significance value between the motor skills of stunted and normal children in this study, a normality test was carried out using Shapiro-Wilk. The results showed that there was inconsistency/non-normality in each variable (data) so that normality was ignored.

### Differences in gender (Male/Female) and Nutritional Status (stunting/normal) in FMS

In comparing 2 groups of different genders, there were significant differences between the stunted male group and normal male group and between the stunted female group and normal female group. These differences especially happened in the FMS and OC scores. Analysis showed that stunted boys had significantly lower LM and FMS scores than normal boys ( $P < 0.05$  each). After adjusting the significance level using the t-test method, the scores and groups that had statistically significant differences were obtained. LM: Stunted and normal boy groups (adjusted  $p < 0.05$  each).

As for boys, when comparing the raw scores of specific skills, the 3 LM skills (running, galloping, and sliding) showed statistically significant differences between the two groups.

Six OC skills (striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll) have  $P < 0.05$ . After adjusting the significance level using the Bonferroni method, it was found that skills and gender had significant differences between the 2 groups (all  $P < 0.05$ ). After adjusting the significance level using the paired method, it was found that skills and gender did have statistically significant differences (all adjusted  $P < 0.05$ ). The men's group obtained the highest score in jumping and attacking skills from both the stunting and normal groups. Meanwhile, the women's group got the highest score in hop skills.

Table 5 describes the mean score for children's motor skills between those with stunting and normal status. In the FMS stunting program, the average motor skill was 18.65 with elementary school 1.15. Meanwhile, the FMS program for normal children had an average of motor skills of 36.52 with  $\pm$  sd 0.36.

Table 5.  
Paired Samples Test

Sumbat Statistics	n	Man		Woman		Total
		Raw Score Lokomotor	Raw Score Control objects	Raw Score Lokomotor	Raw Score Control objects	
		Stunting	x	19,25	19,92	
	sd	8,14	6,89	5,38	6,36	1,15
	n	463,00	408,00	470,00	413,00	1754,00
Normal	x	38,50	34,00	39,17	34,42	36,52
	sd	2,75	2,45	1,99	1,93	0,39

### Discussion

The researchers' main findings indicate that children with stunting tend to have lower levels of motor skills compared to non-stunting children. This is consistent with previous research showing a relationship between physical growth and motor development in childhood (Arruda et al., 2022). An investigation of 48 preschool children aged between 3–5 years from preschools throughout South Solok showed that BMI and nutritional status had minimal influence on FMS skills (Niemistö, Finni, Haapala, Cantell,

& Sääkslahti, 2019). In our study, to clarify the relationship between BMI and FMS, a correlation analysis was run. The results were consistent with previous studies, and the correlation was very weak.

Scholars argue that linear growth failure serves as a marker for a variety of pathological disorders, such as increased morbidity and mortality, loss of physical growth potential, decreased neurodevelopmental and cognitive function, and increased risk of chronic disease in adulthood (López-Valenciano, Ayala, De Ste Croix, Barbado, & Vera-Garcia, 2019; Phytanza, Burhaein, & Pavlovic, 2021). The severe irreversible physical and neurocognitive damage that accompanies stunted growth represents a major threat to human development. Therefore, increasing awareness of the magnitude of stunting and its devastating consequences is critical and perceived as a key global health priority. This has become the focus of the international community at the highest levels, with global targets set for 2025 and beyond (Griffiths, Toovey, Morgan, & Spittle, 2018; Luengo et al., 2019).

Stunting is a major contributor to child morbidity and mortality; thus, providing evidence for more effective policies and programs is vital to prevent child malnutrition and the associated lifelong disability. Such evidence is also critical to achieving the global nutrition targets for 2025 adopted by the World Health Assembly and has been proposed as a key indicator for the post-2015 development agenda (Akombi et al., 2017). It is important to note that the early childhood period is a critical time to promote physical activity. The health benefits of vigorous physical activity from dawn have not been confirmed. It is recommended that physical activity be encouraged in young children to help develop their motor skills (McCoy et al., 2020; Oktavia et al., 2019).

Several studies have shown gender differences in fundamental motor skills (FMS) proficiency, with boys tending to score higher than girls (Bala & Katić, 2009). However, evidence regarding gender differences in locomotor skills remains inconsistent, with some studies reporting superiority in girls (Kim, Carlson, Curby, & Winsler, 2016; Zhou et al., 2023). Moreover, other studies support the current findings that there was no significant difference between boys and girls (Oberer, Gashaj, & Roebbers, 2017).

Another study (Arini, Mayasari, & Rustam, 2019) showed that a relationship was found between the degree of stunting and impaired cognitive and motor development in children. Research (Mastuti & Indahwati, 2021b) reported that children who experienced stunting had lower personal social, language, fundamental, and fine motor development scores compared to children who did not experience stunting. The results of research by Susiani (2019) showed that the fine motor development status in the suspected stunting category of toddlers with stunting was higher (71.7%) compared to non-stunting (47.4%). It was found that fundamental motor development status in

the suspect category of stunted toddlers was higher (60.4%) than non-stunting children (35.1%). There are differences in the development of fine motor skills and fundamental motor skills in stunting and non-stunting children with values ( $P=0.016$  and  $P=0.014$ ).

One reason may be that at ages 3 to 5, boys and girls are biologically similar, but gender roles and social perceptions may influence how they engage in competitive activities. This may result in differences in the performance of certain motor skills (Houwen, van der Veer, Visser, & Cantell, 2017; Roebbers et al., 2014). In this study, girls showed significantly better performance in locomotor skills, such as jumping, hopping, and sliding, compared with boys. Therefore, in analyzing the influence of environment and ethnicity on FMS, research subjects were divided into groups of boys and girls. If left untreated, low motor skills can have a negative impact on a child's physical, cognitive, and social development, as well as an active lifestyle (Michel & Molitor, 2022; van der Fels et al., 2015). Motor skills are a person's ability to carry out movements or physical activities that require coordination between muscles, nerves, and sensory systems. They can be divided into two categories, namely fundamental motor skills and fine motor skills (Vidranski, 2015).

Handling stunting in the form of providing nutritious food and accompanied by physical activity in the form of traditional games for school children is very necessary (Welis, Darni, Khairuddin, Rifki, & Chaeroni, 2022). Fundamental motor skills are needed as a basis for developing motor skills in the future (Pranoto, Sibomana, et al., 2023). These skills are children's basic movements that should be mastered in childhood (Harris, Alnedral, Taufan, Aulia, & Gusril, 2023). Regardless of the importance of these skills, data about them among children, both preschool and elementary school children, in Indonesia are still limited due to a lack of understanding of these disciplines in Indonesia (Bakhtiar, 2014). In fact, lack of physical activity will cause various kinds of problems, especially related to cardiovascular disease, obesity, and difficulty in solving problems. Scholars suggest that endurance and strength physical activity programs can increase the life satisfaction of obese children and even increase the satisfaction of their school life (Chaeroni, Komaini, Pranoto, & Antoni, 2022). Under normal conditions, children, especially kindergarteners, acquire and apply these motor skills in the school environment (Pranoto, Chaeroni, Rifki, Ilham, & Susanto, 2023).

In this study, children's FMS performance varied across environments. The FMS scores of children in this area were lower than in other areas. These findings are consistent with research from other countries (Galdi, D'Anna, Pastena, & Paloma, 2015; Weston, Siegler, Bahnert, McBrien, & Lovell, 2015). Research shows that low-income children in rural areas perform significantly better than high-income children in urban areas and low-income children in urban areas ( $P=0.028$  and  $P=0.009$ , respectively). Other research focused on socioeconomic and family factors and

found that children living below the poverty line tended to have better fundamental motor skills. In addition, they discovered that girls had better locomotor skills than boys (Leroy & Frongillo, 2019a; Zeng et al., 2017). Children from rural areas have the potential to spend more outdoor time. Differently, children from metropolitan areas are most often involved in organized sports (Black et al., 2008; Eliasson et al., 2006). It is unclear whether ethnicity influences the development of FMS in young children. Previous results have been mixed. A 3-year longitudinal study of 313 kindergartners, for instance, showed that Hispanic children greatly increased sedentary behavior and lower MVPA than non-Hispanic children (Zhang, Chen, & Gu, 2020).

In contrast, studies investigating FMS in catching, balancing, and jumping in 4- to 12-year-old Euro-American children (N=103) and Mexican-American children (N=104) found no significant differences between the two groups in these tasks (Keskinen et al., 2015). Only, we observed that they found no ethnic differences because many activities were similar in both cultures during the early years of childhood. In contrast, in Eyre's study, in the white and South Asian groups, at baseline, there were significant differences between ethnicities in running, stationary dribbling, throwing, tumbling, 7-skill scores, and medicine ball throwing. The majority of South Asian children were categorized as those with poorer motor performance on the skill component and/or White children had higher levels of mastery of the motor component (Saidmamatov, Nascimento, Cerqueira, Rodrigues, & Vasconcelos, 2022).

Stunting can affect the development of the brain and central nervous system, which play a key role in coordinating body movements and motor skills. Children who experience stunting may face challenges in developing their motor skills, such as running, jumping, and performing other movements (Mudadu Silva et al., 2023b; Taib & Ismail, 2021).

Apart from nutritional aspects, psychosocial factors also play an important role. Children who are stunted may face stress and a lack of optimal stimulation, which can affect the development of their motor skills. Appropriate interventions can help reverse the impact of stunting on central nervous system development and motor skills. (Leroy & Frongillo, 2019b). These simulations include providing adequate nutrition and a supportive environment for development. Prevention and early intervention efforts can also play a role in ensuring children have the best opportunity to develop their potential motor skills (de Onis & Branca, 2016b). In this context, a holistic approach, including nutrition, environmental stimulation, and psychosocial support, can be the key to improving the health and development of children experiencing stunting (Prendergast & Humphrey, 2014b; Rahman et al., 2018).

Finally, our main finding indicates that most children's FMS skills are strongly influenced by nutritional status. The FMS skills of most stunted children are worse than normal

children. Such findings are common in both boys and girls. Skill differences between genders are quite diverse and the specific reasons are not explained in this study. Compared to girls, boys' skills are more influenced by region and ethnicity. The skills that are different between the women's groups are also different in the men's groups. Conversely, some skills are different in boys but not different in girls. From a physiological point of view, although there are no obvious physiological differences between boys and girls in early childhood, boys tend to have easier access to activities and encouragement. They also have more opportunities to participate in competitive play, which causes differences in skill performance between boys and girls.

### Research limitations

Despite the promising results, caution is required in interpreting the results, and some limitations must be acknowledged. First, many factors can influence research results. These include each child's individual characteristics, such as age of independent walking, time spent sitting still and outdoors, participation in organized sports activities, and access to electronic devices. Family factors also play a role, including parental education level, physical frequency, and sedentary behavior. Another factor is the children's environment, such as the use of sports facilities. Delayed development of motor competence is also associated with decreased health-promoting physical activity, physical fitness, perceived competence, and increased obesity (Dapp, Gashaj, & Roebers, 2021). Other factors that may be important but have not been considered or for which data are not available include outdoor exposure, community recreational activities, and genetic predisposition. However, research usually focuses on limited factors; no comprehensive studies have been conducted. Due to the complexity of influencing factors, the reasons for related differences between groups will be addressed in further research.

Another limitation is that only one process-oriented tool was used. Thus, certain FMS (such as stability skills) were not checked in this research. Although the TGMD-2 is a valid tool that has been used in many international studies, further research should consider the use of more than one tool to evaluate FMS comprehensively.

### Conclusion

In this study, children with different nutritional statuses showed certain characteristics in FMS, indicating that they were influenced by nutritional status and gender. This research confirmed that boys and girls with stunting status had poorer abilities in carrying out certain skills than others and performed better in other skills. This suggests that certain population groups may require a special focus on interventions to improve their FMS levels. Further research will provide greater clarity for improving targeted FMS interventions.

## References

- Akombi, B. J., Agho, K. E., Hall, J. J., Merom, D., Astell-Burt, T., & Renzaho, A. M. N. (2017). Stunting and severe stunting among children under-5 years in Nigeria: A multilevel analysis. *BMC Pediatrics*, *17*(1), 1–16. <https://doi.org/10.1186/s12887-016-0770-z>
- Akseer, N., Tasic, H., Nnachebe Onah, M., Wigle, J., Rajakumar, R., Sanchez-Hernandez, D., ... Hoddinott, J. (2022). Economic costs of childhood stunting to the private sector in low- and middle-income countries. *EClinicalMedicine*, *45*. <https://doi.org/10.1016/j.eclinm.2022.101320>
- Arini, D., Mayasari, A. C., & Rustam, M. Z. A. (2019). Motor and Cognitive Development Disorders in Toddler Children with Stunting in the Coastal Area of Surabaya. *Journal of Health Science and Prevention*, *3*(2), 122–128.
- Arruda, R. C. B. F. de, Tassitano, R. M., da Silva Brito, A. L., de Sousa Martins, O. S., Cabral, P. C., & de Castro Antunes, M. M. (2022). Physical activity, sedentary time and nutritional status in Brazilian children with cerebral palsy. *Jornal de Pediatria*, *98*(3), 303–309. <https://doi.org/10.1016/j.jped.2021.07.005>
- Aye, T., Oo, K. S., Khin, M. T., Kuramoto-Ahuja, T., & Maruyama, H. (2017). Gross motor skill development of 5-year-old Kindergarten children in Myanmar. *Journal of Physical Therapy Science*, *29*(10), 1772–1778. <https://doi.org/10.1589/jpts.29.1772>
- Bakhtiar, S. (2014). Fundamental motor skill among 6-year-old children in Padang, West Sumatera, Indonesia. *Asian Social Science*, *10*(5), 155–158. <https://doi.org/10.5539/ass.v10n5p155>
- Bala, G., & Katić, R. (2009). (n.d.). *Bala, G., & Katić, R. (2009). Sex differences in anthropometric characteristics, motor and cognitive functioning in preschool children at the time of school enrolment. Collegium antropologicum, 33(4), 1071–1078.*
- Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., ... Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet*. [https://doi.org/10.1016/S0140-6736\(07\)61690-0](https://doi.org/10.1016/S0140-6736(07)61690-0)
- Bossavit, B., & Arnedillo-Sánchez, I. (2023). Motion-based technology to support motor skills screening in developing children: A scoping review. *Computer Methods and Programs in Biomedicine*, *240*(July). <https://doi.org/10.1016/j.cmpb.2023.107715>
- Chaeroni, A., Komaini, A., Pranoto, N. W., & Antoni, D. (2022). The Effect of Physical Activity Programs and School Environments on Movement Activities and Mental Health. *International Journal of Human Movement and Sports Sciences*, *10*(2), 131–137. <https://doi.org/10.13189/saj.2022.100201>
- Dapp, L. C., Gashaj, V., & Roebbers, C. M. (2021). Physical activity and motor skills in children: A differentiated approach. *Psychology of Sport and Exercise*, *54*(February), 101916. <https://doi.org/10.1016/j.psychsport.2021.101916>
- de Onis, M., & Branca, F. (2016a). Childhood stunting: A global perspective. *Maternal and Child Nutrition*, *12*, 12–26. <https://doi.org/10.1111/mcn.12231>
- de Onis, M., & Branca, F. (2016b). Childhood stunting: A global perspective. *Maternal and Child Nutrition*, *12*, 12–26. <https://doi.org/10.1111/mcn.12231>
- Eliasson, A. C., Krumlinde-Sundholm, L., Rösblad, B., Beckung, E., Arner, M., Öhrvall, A. M., & Rosenbaum, P. (2006). The Manual Ability Classification System (MACS) for children with cerebral palsy: Scale development and evidence of validity and reliability. *Developmental Medicine and Child Neurology*, *48*(7), 549–554. <https://doi.org/10.1017/S0012162206001162>
- Faber, L., van den Bos, N., Houwen, S., Schoemaker, M. M., & Rosenblum, S. (2022). Motor skills, visual perception, and visual-motor integration in children and youth with Autism Spectrum Disorder. *Research in Autism Spectrum Disorders*, *96*(September 2021), 101998. <https://doi.org/10.1016/j.rasd.2022.101998>
- Galdi, M., D'Anna, C., Pastena, N., & Paloma, F. G. (2015). Gross-motor Skills for Potential Intelligence Descriptive Study in a Kindergarten. *Procedia - Social and Behavioral Sciences*, *174*, 3797–3804. <https://doi.org/10.1016/j.sbspro.2015.01.1115>
- Gandotra, A., Kotyuk, E., Szekely, A., Kasos, K., Csirmaz, L., & Cserjesi, R. (2020). Fundamental movement skills in children with autism spectrum disorder: A systematic review. *Research in Autism Spectrum Disorders*, *78*(January), 101632. <https://doi.org/10.1016/j.rasd.2020.101632>
- Griffiths, A., Toovey, R., Morgan, P. E., & Spittle, A. J. (2018). Psychometric properties of gross motor assessment tools for children: A systematic review. *BMJ Open*, *8*(10), 1–14. <https://doi.org/10.1136/bmjopen-2018-021734>
- Haris, F., Alnedral, Taufan, J., Aulia, F., & Gusril. (2023). The effect of Motor Coordination Learning (MCL) based on a combination of e-book and QR-Code media with sign language to improve Basic Movement Skill (BMS) in deaf children: An inclusion education research. *Journal of Physical Education and Sport*, *23*(12), 3349–3355. <https://doi.org/10.7752/jpes.2023.12383>
- Houwen, S., van der Veer, G., Visser, J., & Cantell, M. (2017). The relationship between motor performance and parent-rated executive functioning in 3- to 5-year-old children: What is the role of confounding variables? *Human Movement Science*, *53*, 24–36. <https://doi.org/10.1016/j.humov.2016.12.009>
- Jones, D., Innerd, A., Giles, E. L., & Azevedo, L. B. (2020). Association between fundamental motor skills and physical activity in the early years: A systematic review and meta-analysis. *Journal of Sport and Health Science*, *9*(6), 542–552.



- <https://doi.org/10.1016/j.jshs.2020.03.001>
- Keskinen, E., Marttila, A., Marttila, R., Jones, P. B., Murray, G. K., Moilanen, K., ... Miettunen, J. (2015). Interaction between parental psychosis and early motor development and the risk of schizophrenia in a general population birth cohort. *European Psychiatry*, 30(6), 719–727.
- <https://doi.org/10.1016/j.eurpsy.2015.04.006>
- Kim, H., Carlson, A. G., Curby, T. W., & Winsler, A. (2016). Relations among motor, social, and cognitive skills in pre-kindergarten children with developmental disabilities. *Research in Developmental Disabilities*, 53–54, 43–60. <https://doi.org/10.1016/j.ridd.2016.01.016>
- Leroy, J. L., & Frongillo, E. A. (2019a). Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. *Advances in Nutrition*, 10(2), 196–204. <https://doi.org/10.1093/advances/nmy101>
- Leroy, J. L., & Frongillo, E. A. (2019b). Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. *Advances in Nutrition*, 10(2), 196–204. <https://doi.org/10.1093/advances/nmy101>
- Liu, X., Liang, Y., & Chen, K. Z. (2024). Dairy trade liberalization and child stunting: Evidence from low- and middle-income countries. *Food Policy*, 122, 102554. <https://doi.org/10.1016/J.FOODPOL.2023.102554>
- López-Valenciano, A., Ayala, F., De Ste Croix, M., Barbado, D., & Vera-Garcia, F. J. (2019). Different neuromuscular parameters influence dynamic balance in male and female football players. *Knee Surgery, Sports Traumatology, Arthroscopy*, 27(3), 962–970. <https://doi.org/10.1007/s00167-018-5088-y>
- Luengo, M. H., Álvarez-Bueno, C., Pozuelo-Carrascosa, D. P., Berlanga-Macías, C., Martínez-Vizcaino, V., & Notario-Pacheco, B. (2019). Relationship between breast feeding and motor development in children: Protocol for a systematic review and meta-analysis. *BMJ Open*, 9(9). <https://doi.org/10.1136/bmjopen-2019-029063>
- Mastuti, N. L. P. H., & Indahwati, L. (2021a). Pengaruh Stunting Terhadap Perkembangan Motorik Halus, Motorik Kasar, Bahasa Dan Personal Sosial Pada Anak Balita Usia 2-5 Tahun Di Desa Madiredo Kecamatan Pujon Kabupaten Malang. *Journal of Issues In Midwifery*, 5(3), 111–120. <https://doi.org/10.21776/ub.joim.2021.005.03.2>
- Mastuti, N. L. P. H., & Indahwati, L. (2021b). Pengaruh Stunting Terhadap Perkembangan Motorik Halus, Motorik Kasar, Bahasa Dan Personal Sosial Pada Anak Balita Usia 2-5 Tahun Di Desa Madiredo Kecamatan Pujon Kabupaten Malang. *Journal of Issues In Midwifery*, 5(3), 111–120. <https://doi.org/10.21776/ub.joim.2021.005.03.2>
- McCoy, S. W., Palisano, R., Avery, L., Jeffries, L., Laforme Fiss, A., Chiarello, L., & Hanna, S. (2020). Physical, occupational, and speech therapy for children with cerebral palsy. *Developmental Medicine and Child Neurology*, 62(1), 140–146. <https://doi.org/10.1111/dmcn.14325>
- McKenzie, T. L., Sallis, J. F., Broyles, S. L., Zive, M. M., Nader, P. R., Berry, C. C., & Brennan, J. J. (2002). Childhood movement skills: Predictors of physical activity in anglo american and mexican american adolescents? *Research Quarterly for Exercise and Sport*, 73(3), 238–244. <https://doi.org/10.1080/02701367.2002.10609017>
- Michel, E., & Molitor, S. (2022). Fine motor skill automatization and working memory in children with and without potential fine motor impairments: An explorative study. *Human Movement Science*, 84. <https://doi.org/10.1016/j.humov.2022.102968>
- Mudadu Silva, J. R., Vieira, L. L., Murta Abreu, A. R., de Souza Fernandes, E., Moreira, T. R., Dias da Costa, G., & Mitre Cotta, R. M. (2023a). Water, sanitation, and hygiene vulnerability in child stunting in developing countries: a systematic review with meta-analysis. *Public Health*, 219, 117–123. <https://doi.org/10.1016/j.puhe.2023.03.024>
- Mudadu Silva, J. R., Vieira, L. L., Murta Abreu, A. R., de Souza Fernandes, E., Moreira, T. R., Dias da Costa, G., & Mitre Cotta, R. M. (2023b). Water, sanitation, and hygiene vulnerability in child stunting in developing countries: a systematic review with meta-analysis. *Public Health*, 219, 117–123. <https://doi.org/10.1016/j.puhe.2023.03.024>
- Niemistö, D., Finni, T., Haapala, E. A., Cantell, M., & Sääkslahti, A. (2019). Environmental correlates of motor skills in children – the Skilled Kids Study. *International Journal of Environmental Research and Public Health*, 16, 1–17.
- O' Brien, W., Belton, S., & Issartel, J. (2016). Fundamental movement skill proficiency amongst adolescent youth. *Physical Education and Sport Pedagogy*, 21(6), 557–571. <https://doi.org/10.1080/17408989.2015.1017451>
- Oberer, N., Gashaj, V., & Roebbers, C. M. (2017). Motor skills in kindergarten: Internal structure, cognitive correlates and relationships to background variables. *Human Movement Science*, 52, 170–180. <https://doi.org/10.1016/j.humov.2017.02.002>
- Oktavia, D., Bali, M., Rahman, H., Umar, U., Syakroni, A., & Widat, F. (2019). *Exploration of Fine Motor Skills through the Application of Paint*. <https://doi.org/10.4108/eai.8-12-2018.2284038>
- Phytanza, D. T. P., Burhaein, E., & Pavlovic, R. (2021). Gross motor skills levels in children with autism spectrum disorder during the covid-19 pandemic. *International Journal of Human Movement and Sports Sciences*, 9(4), 738–745. <https://doi.org/10.13189/saj.2021.090418>
- Pranoto, N. W., Chaeroni, A., Rifki, M. S., Ilham, & Susanto, N. (2023). The Effects of Inactivity During The COVID-19 Pandemic on the Psychomotor Skills of Kindergarten Students. *Annals of Applied Sport Science*, 11(2). <https://doi.org/10.52547/aassjournal.1162>

- Pranoto, N. W., Sibomana, A., Ndayisenga, J., Chaeroni, A., Fauziah, V., Susanto, N., ... Rayendra, R. (2023). Development of a disaster mitigation learning program for kindergarten students through physical fun games. *Journal of Physical Education and Sport*, 23(12), 3228–3234. <https://doi.org/10.7752/jpes.2023.12369>
- Prendergast, A. J., & Humphrey, J. H. (2014a). The stunting syndrome in developing countries. *Paediatrics and International Child Health*, 34(4), 250–265. <https://doi.org/10.1179/2046905514Y.0000000158>
- Prendergast, A. J., & Humphrey, J. H. (2014b). The stunting syndrome in developing countries. *Paediatrics and International Child Health*, 34(4), 250–265. <https://doi.org/10.1179/2046905514Y.0000000158>
- Rahman, M., Haque, S. E., Zahan, S., Islam, J., Rahman, M., Asaduzzaman, M. D., ... Mostofa, G. (2018). Maternal high-risk fertility behavior and association with chronic undernutrition among children under age 5 y in India, Bangladesh, and Nepal: Do poor children have a higher risk? *Nutrition*, 49, 32–40. <https://doi.org/10.1016/j.nut.2017.10.001>
- Roebers, C. M., Röthlisberger, M., Neuenschwander, R., Cimeli, P., Michel, E., & Jäger, K. (2014). The relation between cognitive and motor performance and their relevance for children's transition to school: A latent variable approach. *Human Movement Science*, 33(1), 284–297. <https://doi.org/10.1016/j.humov.2013.08.011>
- Rukiko, M. D., Mwakalobo, A. B. S., & Mmasa, J. J. (2023). The impact of Conditional Cash Transfer program on stunting in under five year's poor children. *Public Health in Practice*, 6(October), 100437. <https://doi.org/10.1016/j.puhip.2023.100437>
- Saidmamatov, O. A., Nascimento, M. M., Cerqueira, J. C., Rodrigues, P., & Vasconcelos, O. (2022). Motor skill training programs for children with developmental coordination disorder: Does gender matter? *Neuropsychiatrie de l'Enfance et de l'Adolescence*, 70(4), 183–194. <https://doi.org/10.1016/j.neurenf.2022.03.001>
- Sulistiyowati, E. M., Suherman, W. S., Sukanti, E. R., Ilham, Sriwahyuniati, F., Budiarti, R., & Pranoto, N. W. (2022). Development of Early Childhood Skills by Guiding Tests in Sports Rhythmic Gymnastics. *International Journal of Human Movement and Sports Sciences*, 10(2), 253–263. <https://doi.org/10.13189/saj.2022.100216>
- Taib, W. R. W., & Ismail, I. (2021). Evidence of stunting genes in Asian countries: A review. *Meta Gene*, 30. <https://doi.org/10.1016/j.mgene.2021.100970>
- Thurstans, S., Sessions, N., Dolan, C., Sadler, K., Cichon, B., Isanaka, S., ... Khara, T. (2022). The relationship between wasting and stunting in young children: A systematic review. *Maternal and Child Nutrition*, 18(1). <https://doi.org/10.1111/mcn.13246>
- Van Biesen, D., Van Damme, T., Pineda, R. C., & Burns, J. (2022). The impact of intellectual disability and sport expertise on cognitive and executive functions. *Journal of Intellectual Disabilities*. <https://doi.org/10.1177/17446295211036331>
- van der Fels, I. M. J., te Wierike, S. C. M., Hartman, E., Elferink-Gemser, M. T., Smith, J., & Visscher, C. (2015). The relationship between motor skills and cognitive skills in 4–16 year old typically developing children: A systematic review. *Journal of Science and Medicine in Sport*, 18(6), 697–703. <https://doi.org/10.1016/J.JSAMS.2014.09.007>
- Vidranski, T. (2015). *Keterampilan Motorik pada Anak Tunarungu dengan atau tanpa Implan Rumah Siput – Tinjauan Sistematis*. 39, 173–179.
- Webster, E. K., Martin, C. K., & Staiano, A. E. (2019). Fundamental motor skills, screen-time, and physical activity in preschoolers. *Journal of Sport and Health Science*, 8(2), 114–121. <https://doi.org/10.1016/j.jshs.2018.11.006>
- Welis, W., Darni, Khairuddin, Rifki, M. S., & Chaeroni, A. (2022). Effect of Stunting Handling and Physical Activity on Motor Ability and Concentration of School Children. *International Journal of Human Movement and Sports Sciences*, 10(5), 1040–1046. <https://doi.org/10.13189/saj.2022.100522>
- Weston, M., Siegler, J., Bahnert, A., McBrien, J., & Lovell, R. (2015). The application of differential ratings of perceived exertion to Australian Football League matches. *Journal of Science and Medicine in Sport*, 18(6), 704–708. <https://doi.org/10.1016/j.jsams.2014.09.001>
- Zeng, N., Ayyub, M., Sun, H., Wen, X., Xiang, P., & Gao, Z. (2017). Effects of physical activity on motor skills and cognitive development in early childhood: A systematic review. *BioMed Research International*, 2017. <https://doi.org/10.1155/2017/2760716>
- Zhang, D., Soh, K. G., Chan, Y. M., & Zaremohzzabieh, Z. (2023). Effect of intervention programs to promote fundamental motor skills among typically developing children: A systematic review and meta-analysis. *CHILDREN AND YOUTH SERVICES REVIEW*, 107320. <https://doi.org/10.1016/j.childyouth.2023.107320>
- Zhang, X., Chen, S., & Gu, X. (2020). Ethnic Disparities in Mental Health and Movement Behaviors During Childhood: Examining the Longitudinal Developmental Patterns. *Journal of Racial and Ethnic Health Disparities*, 7(6), 1249–1257. <https://doi.org/10.1007/s40615-020-00750-6>
- Zhou, L., Liang, W., He, Y., Duan, Y., Rhodes, R. E., Lippke, S., ... Liu, Q. (2023). A school-family blended multi-component physical activity program for Fundamental Motor Skills Promotion Program for Obese Children (FMSPPPOC): protocol for a cluster randomized controlled trial. *BMC Public Health*, 23(1), 369. <https://doi.org/10.1186/S12889-023-15210-Z>

### Datos de los autores y traductor:

Nuridin Widya Pranoto	nuridin@fik.unp.ac.id	Autor/a
Varhatun Fauziah	fauziah44342@gmail.com	Autor/a
Arif Fadli Muchlis	arif_fmuchlis@fik.unp.ac.id	Autor/a
Anton Komaini	antonkomaini@fik.unp.ac.id	Autor/a
Rayendra Rayendra	rayendra@fip.unp.ac.id	Autor/a
PreferenciasNugroho Susanto	nugrohosusanto@fik.unp.ac.id	Autor/a
PreferenciasGema Fitriady	gema.fitriady.fik@um.ac.id	Autor/a
PreferenciasHendra Setyawan	hendra7777setyawan@uny.ac.id	Autor/a
PreferenciasRatko Pavlovic	pavlovicratko@yahoo.com	Autor/a
PreferenciasAlexandre Sibomana	alexamana37@gmail.com	Autor/a
Japhet ndayisenga	ndayisengajaphet@gmail.com	Autor/a
Mhs proofreading	+62 85750966821	Traductor/a