



Original Article

Gross motor skill development of kindergarten children in Japan

THANDA AYE, RPT, PhD^{1, 2)*}, TSUGUMI KURAMOTO-AHUJA, RPT, MA¹⁾,
TAMAE SATO, RPT, MS¹⁾, KAORI SADAKIYO, RPT, MS¹⁾, MIYOKO WATANABE, RPT, PhD¹⁾,
HITOSHI MARUYAMA, RPT, PhD¹⁾

¹⁾ International University of Health and Welfare: 2600-1 Kitakanemaru, Otawara city,
Tochigi 324-8501, Japan

²⁾ University of Medical Technology, Yangon, Ministry of Health and Sports,
Republic of the Union of Myanmar

Abstract. [Purpose] The purposes of this study were to assess and explore the gender-based differences in gross motor skill development of 5-year-old Japanese children. [Subjects and Methods] This cross-sectional study recruited 60 healthy 5-year-old (third-year kindergarten, i.e., *nencho*) children (34 boys, 26 girls) from one local private kindergarten school in Otawara city, Tochigi Prefecture, Japan. Gross motor skills, including six locomotor and six object control skills, were assessed using the test of gross motor development, second edition (TGMD-2). All subjects performed two trials of each gross motor skill, and the performances were video-recorded and scored. Assessment procedures were performed according to the standardized guidelines of the TGMD-2. [Results] The majority of subjects had an average level of overall gross motor skills. Girls had significantly better locomotor skills. Boys had significantly better object control skills. [Conclusion] The gross motor skill development of 5-year-old Japanese children involves gender-based differences in locomotor and object control skills. This study provided valuable information that can be used to establish normative references for the gross motor skills of 5-year-old Japanese children.

Key words: Gross motor skill development, Kindergarten, Children

(This article was submitted Dec. 7, 2017, and was accepted Feb. 27, 2018)

INTRODUCTION

Development is a process through which individuals change across their lifespan¹⁾. Human development can be divided into four main domains: cognitive, affective (socioemotional), motor, and physical^{1, 2)}. Payne and Isaacs have reported that motor development has profound effects on the development of cognitive, social, and physical behaviors²⁾. They reported that knowledge of motor development (movement skills) can be useful for diagnosing problems in individuals who may be developing abnormally and is important for helping individuals improve their motor performance by undertaking developmentally appropriate activities²⁾. Haywood and Getchell have reported that motor development refers to the continuous, age-related process of changes in movement as well as the interacting constraints of the individual, environment, and tasks that drive these changes³⁾. Effgen has reported that movement is the domain of physical therapists and it is necessary to have a thorough understanding of the normal acquisition, fluency, maintenance, and generalization of motor skills to comprehend their influence on activities and participation⁴⁾. The existing literature has highlighted that early assessment of the development of gross motor skills during preschool and elementary school years is particularly important for monitoring changes in motor development, identifying delays or deficits in development and assisting physical therapists and other healthcare

*Corresponding author. Thanda Aye (E-mail: 15s3027@g.iuhw.ac.jp)

©2018 The Society of Physical Therapy Science. Published by IPEC Inc.



This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: <https://creativecommons.org/licenses/by-nc-nd/4.0/>)

practitioners for properly designing exercise programs^{5, 6}).

Several standardized assessment tools for the gross motor skill development of children are used in clinical, educational, and research settings⁷⁻¹⁰. One of the most widely used tools for assessing the gross motor skill development of children is the test of gross motor development, second edition (TGMD-2)⁷⁻¹⁰. TGMD-2 is a standardized process-oriented, criterion-referenced, and norm-referenced test that measures the gross motor abilities of children between 3 and 10 years of age^{6, 10}. It is used to identify children who are significantly behind their peers in gross motor skill development, to plan instructional programs for gross motor skill development, to assess individual progress in gross motor skill development, and to evaluate the success of the gross motor program; it also serves as a measurement instrument for gross motor development research⁶. TGMD-2, which was first developed in the United States, has been confirmed as a reliable, valid, and well-standardized assessment tool for measuring the gross motor skill development of children with and without disabilities⁶).

TGMD-2 evaluates 12 gross motor skills that are divided into locomotor and object control subtests⁶. The locomotor subtest includes running, galloping, hopping, leaping, horizontal jumping, and sliding⁶. The object control subtest includes striking a stationary ball, stationary dribbling, catching, kicking, overhand throwing, and underhand rolling⁶. Ulrich reported that the items of the TGMD-2 are the fundamental gross motor behaviors of children during preschool and early elementary school years⁶. The time taken to complete the TGMD-2 test for one child is 15–20 minutes, and the directions for scoring items are clearly written in the examiner's manual; therefore, professionals can administer the TGMD-2 with minimal training⁶. There are four performance criteria for running, galloping, horizontal jumping, and sliding, five criteria for hopping, and three criteria for leaping, resulting in a total of 24 criteria for the locomotor subtest⁶. There are five performance criteria for striking a stationary ball, three for catching, and four for stationary dribbling, kicking, overhand throwing, and underhand rolling, resulting in a total of 24 criteria for the object control subtest⁶. Each skill is performed two times during the assessment, and each criterion is given a score of 1 or 0, indicating pass or fail, respectively⁶. The scores of the two trials are summed to obtain the total criterion score, the total criterion scores for the performance criteria are summed to obtain the skill score, and the six skill scores are summed to obtain the raw subtest score (range, 0–48)⁶. Raw subtest scores are converted to standard scores (range, 1–20) and percentiles (range, <1 to >99) depending on age and gender and according to the normed tables in the TGMD-2 examiner's manual⁶. The standard scores of the locomotor and object control subtests are summed and converted to the Gross Motor Quotient (GMQ) (range, 46–160)⁶. Finally, seven descriptive ratings from very poor to very superior (very poor, poor, below average, average, above average, superior, and very superior) for the subtest standard scores and the GMQ are used for evaluation⁶.

Previous studies using the TGMD-2 to assess the gross motor skill development of children in preschool and elementary school have been conducted in different countries¹¹⁻²⁷. Some studies have found no significant differences between the locomotor skills of boys and girls^{11, 13, 18, 20}), whereas others have found that girls have superior locomotor skills^{15, 16}). Several studies have found that boys have significantly better object control skills^{11, 13, 15-17, 20, 21}).

The locomotor and object control skills of the TGMD-2 are related to activities and games that children are most likely to participate in during the preschool years^{6, 15}). In Japanese, *yochien* means preschool or kindergarten school; these schools offer 1- to 3-year programs for children 3–5 years old. The programs are first-year kindergarten (*nensho*), second-year kindergarten (*nenchu*), and third-year kindergarten (*nencho*) for 3-, 4-, and 5-year-old children, respectively²⁸). To enroll, the child must have reached the appropriate age for the program by April 1 of the entrance year²⁸).

Three researchers involved in this study examined and reported the gross motor skill development of 5-year-old children in Myanmar and found that there were gender-based and region-based (urban and rural) differences¹¹). It would be beneficial to know the mastery level of 5-year-old children in different cultures; however, there is limited information regarding gross motor skill development assessments of only 5-year-old Japanese children using the TGMD-2. Therefore, the purposes of this study were to examine the gross motor skill development of 5-year-old Japanese children and to explore the gender-based differences in the gross motor skill development.

SUBJECTS AND METHODS

This study was a cross-sectional study. Convenience sampling was used to recruit 60 healthy 5-year-old third-year kindergarten (*nencho*) students from one local private kindergarten school in Otawara city, Tochigi Prefecture, Japan. The subjects were 34 boys and 26 girls (age, 5.7 ± 0.31 years; height, 109.8 ± 4.82 cm; weight, 18.4 ± 2.41 kg; body mass index [BMI], 15.2 ± 1.11 kg/m²). BMI was calculated using the BMI percentile calculator for children and teens (metric version online, Centers for Disease Control and Prevention)²⁹). Exclusion criteria were known developmental disability (e.g., cerebral palsy, Down syndrome, autism spectrum disorder, attention deficit hyperactive disorder), obvious deformity (e.g., scoliosis, bow leg), and orthopedic injury in both upper and lower extremities within 6 months. Information regarding this study was provided in the Japanese version of the written information letter and by verbal explanation to the director of the school, teachers, parents or guardians, and students before their voluntary participation. This study was approved by the Ethics Review Committee of the International University of Health and Welfare (IUHW), Japan, on April 5, 2017 (approval number: 16-Io-254). The third-year kindergarten (*nencho*) students and their five kindergarten teachers were invited to the graduate school of IUHW (Otagawa campus) to participate in this study and to have their gross motor skill performances assessed.

The test venue and equipment were set according to the TGMD-2 requirements in three assessment lanes in the experi-

Table 1. Comparisons of gross motor skills between boys and girls

	Total	Boys	Girls		Partial eta squared	Observed power
Number (%)	60 (100)	34 (56.7)	26 (43.3)			
Age (years)	5.70 ± 0.31	5.66 ± 0.30	5.76 ± 0.32			
Height (cm)	109.8 ± 4.82	109.3 ± 4.97	110.3 ± 4.64		0.00	0.08
Weight (kg)	18.4 ± 2.41	18.3 ± 2.43	18.5 ± 2.41		0.01	0.13
BMI (kg/m ²)	15.2 ± 1.11	15.3 ± 1.08	15.2 ± 1.15		0.00	0.06
Run	7.72 ± 0.76	7.71 ± 0.84	7.73 ± 0.67		0.00	0.05
Gallop	6.55 ± 2.24	6.03 ± 2.56	7.23 ± 1.50	*	0.07	0.55
Hop	8.38 ± 2.11	7.79 ± 2.43	9.15 ± 1.26	*	0.10	0.72
Leap	3.17 ± 1.29	2.97 ± 1.31	3.42 ± 1.24		0.03	0.27
Horizontal jump	5.62 ± 2.02	5.38 ± 2.06	5.92 ± 1.96		0.02	0.17
Slide	7.07 ± 1.76	6.71 ± 2.18	7.54 ± 0.81		0.06	0.44
Locomotor raw scores	38.5 ± 5.71	36.6 ± 6.40	41.0 ± 3.36	**	0.15	0.88
Locomotor standard scores	11.7 ± 2.65	11.0 ± 2.76	12.7 ± 2.18	*	0.11	0.75
Locomotor percentiles	66.7 ± 25.0	58.9 ± 27.2	76.8 ± 17.4	**	0.13	0.82
Striking a stationary ball	8.22 ± 1.58	8.65 ± 1.52	7.65 ± 1.52	*	0.10	0.69
Stationary dribble	6.23 ± 2.68	6.18 ± 2.77	6.31 ± 2.62		0.00	0.05
Catch	4.00 ± 1.29	4.00 ± 1.21	4.00 ± 1.41		0.00	0.05
Kick	7.22 ± 1.46	7.68 ± 0.88	6.62 ± 1.83	**	0.13	0.83
Overhand throw	5.73 ± 1.95	6.18 ± 1.98	5.15 ± 1.78	*	0.07	0.53
Underhand roll	4.98 ± 1.80	5.15 ± 1.96	4.77 ± 1.58		0.01	0.12
Object control raw scores	36.4 ± 6.57	37.8 ± 6.24	34.5 ± 6.62	*	0.06	0.50
Object control standard scores	12.0 ± 2.68	11.7 ± 2.51	12.4 ± 2.89		0.02	0.18
Object control percentiles	68.8 ± 24.2	65.8 ± 23.2	72.7 ± 25.3		0.02	0.19
Sum of standard scores	23.7 ± 3.98	22.6 ± 3.74	25.1 ± 3.89	*	0.10	0.70
Gross Motor Quotient	111.1 ± 11.9	107.9 ± 11.2	115.4 ± 11.7	*	0.10	0.70

Mean ± standard deviation.

Significant difference between boys and girls: * $p < 0.05$, ** $p < 0.01$.

ment hall of the graduate school (IUHW, Otawara campus). Subjects were divided into three small groups for the three lanes. Each lane was supervised by two researchers, one kindergarten teacher, and one assistant. The TGMD-2 examiner's record form was the main material used for this study; other materials that were used were 8- to 10-inch bouncy playground balls, 8- to 10-inch soccer balls for children, 4-inch lightweight balls, tennis balls, softballs, 4- to 5-inch square beanbags, colored tape, traffic cones, plastic bats, batting tees, and video cameras.

All subjects were provided with a verbal description in Japanese and a demonstration of each gross motor skill before starting the assessment. Each subject was asked to perform each gross motor skill twice. All subjects wore rubber-soled shoes while performing all TGMD-2 items. The performances of each subject were recorded using a video camera. The position of the camera was changed to record the entire performance of the locomotor skills, and the position and angle of the video camera were fixed to record the object control skills. Assessment procedures were performed according to the standardized guidelines of the TGMD-2 and finished within 2 days for all 60 subjects (July 3, 2017 and July 10, 2017). The video recordings were assessed and rated using the TGMD-2 examiner's record forms by the same researcher. Descriptive statistics and one-way analysis of variance with effect sizes and observed power were used to analyze the data. The significance level was set as $p < 0.05$. Data analysis was performed using IBM SPSS statistic version 22.0 for Windows.

RESULTS

Table 1 shows comparisons of the gross motor skills of boys and girls. Scores for galloping and hopping, raw scores, standard scores, the percentile of the locomotor skills, the sum of the standard scores, and the GMQ of girls were significantly higher than those of boys. Scores for striking, kicking, and throwing and the object control raw scores for boys were significantly higher than those for girls.

DISCUSSION

The subjects demonstrated average (majority; 41.7%; n=25), above average (36.7%; n=22), superior (15.0%; n=9), very superior (3.3%; n=2), or below average (3.3%; n=2) overall gross motor skills according to the GMQ. No subject had poor or very poor overall gross motor skills according to the GMQ. The mean standard scores for the locomotor and object control skills among the Japanese children were better than those of the normative samples from the United States, with a mean score of 10 and a standard deviation of 3 for both types of skills⁶. These findings were similar to those of the studies by Aye et al. in Myanmar and Pang and Fong in Hong Kong^{11, 12}.

In this study, girls performed locomotor skills significantly better than boys, which was in line with the results of previous studies^{15, 16}. Hardy et al. reported that preschool girls in Australia tended to have better mastery of locomotor skills¹⁵. Legear et al. also reported that among kindergarten children girls in Canada had superior locomotor proficiency¹⁶. The gender-based differences in locomotor skills found by this study were different from those in some previous studies^{11, 13, 18}. Aye et al. stated that locomotor skill performances were not significantly different between kindergarten boys and girls in Myanmar¹¹. Goodway et al. reported that no significant differences were found in the locomotor skills of preschool boys and girls from two geographical regions in the United States¹³. Bakhtiar also reported similar findings for 6 year-old boys and girls in Indonesia¹⁸. Lin and Yang found that boys and girls between 6 and 9 years in Taiwan had approximately equal locomotor skills²⁰.

The scores for galloping and hopping of the locomotor skills were better in the girls than the boys. The findings were similar to the existing literature on the development of the fundamental locomotor skills in children^{15, 30, 31}. In the study of Hardy et al. in Australia, the girls had better scores on galloping (5.06 ± 0.33 for girls and 4.38 ± 0.44 for boys) and hopping (6.32 ± 0.39 for girls and 5.02 ± 0.44 for boys) than the boys¹⁵. Payne and Isaacs³⁰ referred to the findings of Halverson and Williams that the development of hopping in the girls were more advanced than the boys in 5-year-old children³¹.

In this study, boys performed significantly better on three out of six individual object control skills and had better total raw skill performance scores. These findings concurred with those of previous studies^{11, 13, 15–17, 20, 21}. In their study, Aye et al. reported that boys performed significantly better on five of six individual object control skills and had better total raw skill performance scores¹¹. There were significant differences in the object control skills of boys among preschoolers from the United States in the study by Goodway et al¹³. The findings of this study agreed with those of the study by Hardy et al., which indicated that boys had better total and individual object control skills, except for catching¹⁵. Better object control skills among boys were also found in the study by LeGear et al¹⁶. Bardid et al. reported that Belgian boys performed object control skills better than did Belgian girls¹⁷. Bakhtiar found that boys had slightly better object control skills than did girls¹⁸. Lin and Yang also reported significant differences in the object control skills, except for catching and kicking, of boys and girls²⁰.

The findings of this study have implications for physical therapists, physical education teachers, and other professionals involved in early childhood care and development programs. The strength of this study was that the gross motor skills were assessed using a standardized process-oriented assessment tool that evaluated performance techniques for each component of a skill⁶.

The main limitations of this study were that the sample size was small and the subjects were only from one local private kindergarten school. Therefore, subjects in this study cannot represent all children in Japan. Further studies involving larger sample sizes and children from all over the country are necessary.

In conclusion, the gross motor skill development of 5-year-old Japanese children involved gender-based differences in locomotor and object control skills. These findings provide valuable information that can be used to establish normative references for gross motor skills of 5-year-old Japanese children, which can be used in future studies.

Funding

None.

Conflict of interest

No conflict of interest was declared.

REFERENCES

- 1) Chambers M, Sugden D: Motor development and change. In: Early years movement skills: description, diagnosis and intervention. Whurr Publishers, 2006, pp 1–11.
- 2) Payne G, Isaacs L: Introduction to motor development. In: Human motor development: a lifespan approach, 9th ed. New York: McGraw Hill, 2016, pp 1–22.
- 3) Haywood KM, Getchell N: Fundamental concepts. In: Life span motor development, 6th ed. Human Kinetics, 2014, pp 3–17.
- 4) Effen SK: Child development. In: Meeting the physical therapy needs of children, 2nd ed. F.A. Davis Company, 2013, pp 41–105.
- 5) Malerba KH: Assessment and testing of infant and child development. In: Tecklin JS. Pediatric Physical Therapy, 5th ed. Lippincott Williams & Wilkins, 2015, pp 69–99.
- 6) Ulrich DA: Test of gross motor development: examiner's manual, 2nd ed. Austin: Pro-Ed publisher, 2000, pp 1–60.

- 7) Connolly BH: Examination and evaluation: tests and administration. In: Therapeutic exercises in developmental disabilities, 3rd ed. SLACK, 2005, pp 21–79.
- 8) Veldman SL, Jones RA, Okely AD: Efficacy of gross motor skill interventions in young children: an updated systematic review. *BMJ Open Sport Exerc Med*, 2016, 2: e000067. [Medline] [CrossRef]
- 9) De Medeiros P, Zequinao MA, Fronza FC, et al.: Motor assessment instruments and psychometric procedures: a systematic review. *Motricidade*, 2016, 12: 64–75.
- 10) Cools W, Martelaer KD, Samaey C, et al.: Movement skill assessment of typically developing preschool children: a review of seven movement skill assessment tools. *J Sports Sci Med*, 2009, 8: 154–168. [Medline]
- 11) Aye T, Oo KS, Khin MT, et al.: Gross motor skill development of 5-year-old Kindergarten children in Myanmar. *J Phys Ther Sci*, 2017, 29: 1772–1778. [Medline] [CrossRef]
- 12) Pang AW, Fong DT: Fundamental motor skill proficiency of Hong Kong children aged 6-9 years. *Res Sports Med*, 2009, 17: 125–144. [Medline] [CrossRef]
- 13) Goodway JD, Robinson LE, Crowe H: Gender differences in fundamental motor skill development in disadvantaged preschoolers from two geographical regions. *Res Q Exerc Sport*, 2010, 81: 17–24. [Medline] [CrossRef]
- 14) Staples KL, Reid G: Fundamental movement skills and autism spectrum disorders. *J Autism Dev Disord*, 2010, 40: 209–217. [Medline] [CrossRef]
- 15) Hardy LL, King L, Farrell L, et al.: Fundamental movement skills among Australian preschool children. *J Sci Med Sport*, 2010, 13: 503–508. [Medline] [CrossRef]
- 16) LeGear M, Greyling L, Sloan E, et al.: A window of opportunity? Motor skills and perceptions of competence of children in kindergarten. *Int J Behav Nutr Phys Act*, 2012, 9: 29 <http://www.ijbnpa.org/content/9/1/29> (Accessed Apr. 12, 2017). [Medline] [CrossRef]
- 17) Bardid F, Huyben F, Lenoir M, et al.: Assessing fundamental motor skills in Belgian children aged 3-8 years highlights differences to US reference sample. *Acta Paediatr*, 2016, 105: e281–e290. [Medline] [CrossRef]
- 18) Bakhtiar S: Fundamental motor skill among 6-year-old children in Padang, West Sumatera, Indonesia. *Asian Soc Sci*, 2014, 10: 155–158. [CrossRef]
- 19) Barnett LM, Ridgers ND, Salmon J: Associations between young children’s perceived and actual ball skill competence and physical activity. *J Sci Med Sport*, 2015, 18: 167–171. [Medline] [CrossRef]
- 20) Lin SJ, Yang SC: Development of fundamental movement skills by children aged six to nine. *Univers J Educ Res*, 2015, 3: 1024–1027. [CrossRef]
- 21) Yang SC, Lin SJ, Tsai CY: Effect of gender, age, and BMI on the development of locomotor skills and object control skills among preschool children. *Percept Mot Skills*, 2015, 121: 873–888. [Medline] [CrossRef]
- 22) Barnett LM, Salmon J, Hesketh KD: More active pre-school children have better motor competence at school starting age: an observational cohort study. *BMC Public Health*, 2016, 16: 1068. [Medline] [CrossRef]
- 23) Robinson LE, Goodway JD: Instructional climates in preschool children who are at-risk. Part I: object-control skill development. *Res Q Exerc Sport*, 2009, 80: 533–542. [Medline]
- 24) Breslin CM, Rudisill ME: The effect of visual supports on performance of the TGMD-2 for children with autism spectrum disorder. *Adapt Phys Activ Q*, 2011, 28: 342–353. [Medline] [CrossRef]
- 25) Jones RA, Riethmuller A, Hesketh K, et al.: Promoting fundamental movement skill development and physical activity in early childhood settings: a cluster randomized controlled trial. *Pediatr Exerc Sci*, 2011, 23: 600–615. [Medline] [CrossRef]
- 26) Kordi R, Nourian R, Ghayour M, et al.: Development and evaluation of a basic physical and sports activity program for preschool children in nursery schools in Iran: an interventional study. *Iran J Pediatr*, 2012, 22: 357–363. [Medline]
- 27) Donath L, Faude O, Hagmann S, et al.: Fundamental movement skills in preschoolers: a randomized controlled trial targeting object control proficiency. *Child Care Health Dev*, 2015, 41: 1179–1187. [Medline] [CrossRef]
- 28) Ministry of Education: Culture, Sports, Science and Technology, Japan <http://www.mext.go.jp/en/policy/education/overview/index.htm> (Accessed Aug. 27, 2017)
- 29) Centers for Disease Control and Prevention (CDC): <https://nccd.cdc.gov/dnpabmi/Calculator.aspx?CalculatorType=Metric> (Accessed Jul. 3 and 10, 2017)
- 30) Payne G, Isaacs L: Fundamental locomotion skills of childhood. In: *Human motor development: A lifespan approach*, 8th ed. New York: McGraw Hill, 2012, pp 352–381.
- 31) Halverson L, Williams K: Developmental sequences for hopping over distance: a pre-longitudinal screening. *Res Q Exerc Sport*, 1985, 56: 37–44. [CrossRef]