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Original Article

The relationship between children's somatotypes, motor examination results, and motor skills: assessing 6- to 10-year-olds

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Abstract. [Purpose] Childhood motor disorders and obesity are major health problems and concerns in children today. We performed a physical examination to test the motor system and motor ability of elementary school children based on their body types. [Participants and Methods] The obesity levels of 161 elementary school students aged six to ten were calculated based on the gender, age, and standard weight for each height category to classify them into somatotype groups, and analyze the relationships among the results of four motor examination items, Physical Fitness Test, and body composition analysis for two groups. [Results] More obese children were unable to reach the floor while performing a standing forward bend compared to non-obese children. In addition, a significant difference was found in the assessment of motor performance while performing side-to-side jumping, and obese children showed better values. Many endomorphic children were also unable to touch the floor with their hands when performing the standing forward bend. Among the items from a physical fitness test, the side-to-side hops revealed significant differences. There were no somatotype-related differences in the results of the body composition analysis. [Conclusion] In children aged six to ten years, somatotype differences were not associated with motor skill or body composition.

Key words: Children, Somatotype, Motor examination

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INTRODUCTION

In Japan with a continuously declining birthrate, reduced opportunities for children to play outdoors with other children and the dissemination of games are inhibiting physical and motor development through play[1)]. Additionally, with lifestyle changes, represented by increasing numbers of nuclear households and families with both parents working, many children are forced to eat alone, raising concerns over possible negative influences on heathy child growth[1)]. Motor disorders are one of the major health problems in children of today. In 2016, the motor examination was incorporated into child health examinations[2, 3)]. In addition to the bipolarization of children's exercise habits into over-exercise and under-exercise, there are social concerns over negative influences of the stay-at-home order during the COVID-19 pandemic on their motor system[4)]. The prevalence of fractures is increasing among children, and an increasing number of obese children and decreased physical activity have been reported to be associated[5–7)]. In the motor examination of children, increases in the number of those advised to visit orthopedic surgery departments/clinics and the prevalence of motor disorders among higher-graders have been noted. However, reports on the motor examination below 10 years of age children are still scarce[8)]. In a model project on the motor examination, the rate of children taking well-balanced meals was low, and 5–8% of children aged

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14 or younger skipped breakfast[9]. The obesity rate begins to increase around the age of 6, temporarily decreases during the junior high school period, and increases again after entering senior high school[10]. It has also been reported that those with over-exercise and higher Body Mass Index values more often complain of musculoskeletal pain[11]. Childhood obesity frequently leads to adulthood obesity, and the risk of cardiovascular diseases increases during adulthood[12–14]. As obesity is called a lifestyle-related disease, and its prevalence is increasing with lifestyle changes, it is important to provide children with accurate information and knowledge about growth and somatotypes as early as possible. There have been many studies examining obese children[15], but few have examined the relationships among elementary school students' somatotypes, motor examination results, and motor skills in Japan. Therefore, this study examined the relationships among 6- to 10 year-old children's somatotypes, motor examination results, and motor skills.

PARTICIPANTS AND METHODS

A total of 161 (male: 86, female: 83, mean age: 7.8 ± 0.1, height: 124.4 ± 6.7 cm, and weight: 24.5 ± 0.4 kg) first- to fourth-grade elementary school students using after-school education facilities in 2 cities were analyzed. There were 55 first-, 43 second-, 30 third-, and 26 fourth-graders. The objective and details of the study, the use of the obtained data only for research purposes, and careful handling of personal information were explained to their parents in writing. Other principles, such as participation based on free will and no disadvantageous treatment for those who decide not to participate, were also explained to the parents to obtain their consent prior to the study. On the day of measurements, the children were provided with an outline of the measurements using simple words, and the study was initiated with their consent. The study was approved by the Ethics Committee of Nishikyushu University (H30-17). In the study, physical therapists directly assessed the children with assistance from students belonging to the Department of Rehabilitation Sciences of the author's university, who performed time and frequency measurements after practicing these assessments for 6 months and being approved by the Ethics Committee.

The children's somatotypes were classified based on the gender, age, and standard weight for each height category (standard weight for height) to measure obesity levels[15]. Children with an obesity level of +20% or higher and −20% or lower were classified into endomorphic and ectomorphic groups, respectively. The calculation formula was as follows: obesity level=[actual weight (kg) − standard weight for height (kg)] / standard weight for height (kg) × 100(%). The coefficient to calculate the standard weight for height and the calculation formula designated by the Japanese Society for Pediatric Endocrinology[16] were used.

For the motor examination, 4 items were adopted from the medication examination for locomotive organ disorder screening, reported by Hayashi et al.[17], to examine the following motor skills: one-leg standing: standing on one leg, and maintaining this position for 5 seconds or longer on both sides; squatting: squatting from a standing position, and completing this movement without stopping in the middle; shoulder elevation: lifting both arms to a shoulder flexion angle of about 180 degrees while standing; and standing forward bend: bending forward while standing, and touching the floor with the fingertips without flexing the knees.

Among the New Physical Fitness Test items for elementary school students, the side-to-side hops, standing long jump, hand grip strength, and sit-ups, which were feasible in an after-school education facility, were conducted to assess the children's motor skills. In the side-to-side hops, one parallel line was drawn on each side 100 cm away from the center line, and the number of hops over these lines were counted for 20 seconds, based on the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) Implementation Guidelines for the New Physical Fitness Test[18]. The measurement was performed twice, and the highest value (number) was adopted. Similarly, in the standing long jump based on these guidelines[18], the children stood with their feet slightly apart and toes aligned before the front edge of the takeoff line, and jumped forward with both legs together to measure the straight line distance (cm) between the middle point between the feet before takeoff and the point where the foot landed, both of which were the closest to the takeoff line. The measurement was performed twice, and the highest value was adopted. For hand grip strength measurement, an analogue hand dynamometer for small children (Takei Scientific Instruments Co., Ltd., Niigata, Japan: Product number: T.K.K. 5825) was used. The children stood with both arms hanging down at their sides, and their maximal hand grip strength was measured twice on both sides to adopt these highest values as their hand grip strength values. In the sit-ups, the children adopted a supine position with their knee flexed at 90 degrees and the measurer holding their knees in place, and the number of times their elbows touched their thighs in 30 seconds was counted, based on the MEXT guidelines[18].

Body composition analysis was performed using the bioelectric impedance method and the portable body composition analyzer InBody430 (InBody Japan Inc., Tokyo, Japan) after confirming the absence of those with pacemakers, which is a contraindication for this device. Among the analysis items, the body water content, protein content, mineral content, body fat mass, lean mass, skeletal muscle mass, and bone mineral content were calculated by dividing each measurement value by the weight (%)[19, 20]. Furthermore, the Skeletal Muscle Mass Index (SMI) was calculated by dividing the skeletal muscle mass by the square of the height.

For statistical processing, the children were divided into 3 groups based on their obesity levels: endomorphic, standard, and ectomorphic. As there were only 2 in the ectomorphic group, comparisons were performed between the endomorphic and standard groups. Normality was confirmed by the Shapiro–Wilk test, and values from each measurement item were compared

by the Mann–Whitney U test and χ^2 test (Fisher's exact test). Statistical analysis was performed using SPSS ver. 26, with the significance level set at 5%.

RESULTS

Among the 161 children, there were 10 (6.2%) in the endomorphic, 149 (92.5%) in the standard, and 2 (1.2%) in the ectomorphic group based on their somatotype. In the motor examination, more obese children were unable to perform forward bending in the standing task than the normal children (Table 1). In the assessment of motor performance, there was a significant difference between the obese and normal groups only in side-to-side jumping, and the obese group performed better than the normal group (Table 2). There were no significant differences in any body composition analysis item (Table 2).

DISCUSSION

In a statistical survey on school health conducted in 2020, the national mean rates of endomorphic and ectomorphic children were 8.8 and 0.6%, respectively, among 7 year-old males, and 7.3 and 0.7%, respectively, among 7 year-old females. Over these 10 years, the rate of endomorphic children has increased, and that of ectomorphic children has remained unchanged or increased as a general tendency[21]. Among elementary school students, both the rates of endomorphs and ectomorphs tend to increase with age[21]. The participants of the present study also showed similar tendencies. Furthermore, the ectomorphic group was small, made up of 2 (1.2%) children, confirming that such children are rare to those under 10 years of age.

With regard to the motor examination, a study involving upper-grade elementary school students reported that obesity influences the duration of one-leg standing and the ability to squat[22]. But few studies on motor examinations and body shape have been conducted in children under 10 years of age. In the present study, many children in the endomorphic compared with standard group were unable to touch the floor with their hands when performing the standing forward bend. Children's

Table 1. The criteria of impossible evaluation of motor examination (n=159)

		Endomorphic group	Standard group	Total
One-leg standing for 5 seconds	Possible	10	148	158
	Impossible	0	0	0
Squatting	Possible	9	143	152
	Impossible	1	6	7
Shoulder elevation	Possible	10	143	153
	Impossible	0	6	6
Standing forward bend*	Possible	6	130	136
	Impossible	4	19	23

*$p<0.05$. χ^2 test.

Table 2. Differences in the results of Physical Fitness Tests and the body composition analysis between the somatotypes

Physical Fitness Test	Endomorphic group (n=10)	Standard group (n=149)
Side-to-side jumping (times)**	37.0 (36.0–40.0)	31.5 (27.0–35.0)
Standing long jump (cm)	133.5 (119.0–162.0)	127.5 (112.0–138.0)
Grip strength (kg)	12.6 (10.7–15.1)	11.2 (9.0–13.1)
Standing on one leg with eyes open (s)	60.0 (60.0–60.0)	60.0 (34.2–60.0)
Curl ups (times)	16.0 (12.0–16.0)	14.0 (10.0–17.0)
Body composition analysis	**Endomorphic group (n=10)**	**Standard group (n=149)**
Total Body Water (%)	61.3 (56.7–64.7)	63.4 (60.0–66.3)
Protein (%)	16.3 (15.2–17.1)	17.0 (16.1–17.8)
Minerals (%)	5.7 (5.3–5.9)	5.7 (5.4–5.9)
Body Fat Mass (%)	16.8 (12.3–22.7)	13.9 (10.3–18.4)
Fat Free Mass (%)	83.3 (77.3–87.7)	86.1 (81.6–89.7)
Skeletal Muscle Mass (%)	42.0 (40.0–44.5)	42.5 (40.3–44.3)
Bone Mineral Content (%)	4.7 (4.3–4.9)	4.7 (4.4–4.9)
SMI (kg/m^2)	4.4 (4.0–4.6)	4.3 (41.0–4.7)

Median (25–75%tile). Mann–Whitney U test. **$p<0.01$. SMI: skeletal muscle mass index.

flexibility has been reported to be correlated with pain symptoms[23]. A correlation between flexibility and balance ability has also been reported[24]. As injuries due to not putting the hands on the ground when falling frequently occur in children[25], the results also indicate the necessity of considering flexibility and pain that influence the motor system, even in children under 10 years of age in the case of endomorphic children. On the other hand, in the Physical Fitness Test, the number of side-to-side hops was significantly higher in the endomorphic than standard group. The side-to-side hops is a parameter of agility, instantaneous power, and whole-body endurance[26], and a study involving adults reported that side-to-side hops results were poorer among those with a higher body fat mass and lower muscle mass ratio[27]. Moreover, a study involving elementary school children, including upper-graders, reported lower levels of motor performance involving body travel among children with higher Rohrer index values due to their weight as a negative factor for this task[28]. In the present study, there were no significant differences in the body fat percentage or skeletal muscle mass between children in the endomorphic group and those of other somatotypes, and the former's results were favorable, indicating that being an endomorph did not affect motor performance.

In short, somatotype differences were not associated with motor skill or body composition problems in children aged 6 to 10 years. It has been reported that children are influenced by the activities and lifestyles of other family members, including parents, during their elementary school period[29]. In this study, motor performance was significantly higher in children with obesity tendencies than normal children, but obesity in school children is said to lead to adult obesity at the rate of 40%[30]. There have been reports of increased risk of motor system diseases and arteriosclerosis in obese adults[30]. In order to prevent future lifestyle-related diseases and locomotive syndrome, it may be important to raise children's and their families' overall health awareness through confirmation of their body composition and motor system, in addition to weight, from children under 10 years of age, when somatotype-related health problems have not yet surfaced, unlike the case of adults. As a study limitation, the limited number of participants may have resulted in biased assessment results, and therefore, further studies involving an increased number of participants are required. The author will longitudinally follow up children's health in Japan facing aging and the declining birthrate.

Funding and Conflict of interest

There are no conflicts of interest and funding to disclose in this study.

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