RELATIONSHIP BETWEEN LOCOMOTOR ORGAN HEALTH STATUS AND PHYSICAL FITNESS TEST IN 5TH GRADE ELEMENTARY SCHOOL STUDENTS

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Abstract

Background: Physical fitness tests determine the current state of physical fitness and athletic ability among children, and the results are widely used as basic administrative data. In 2016, Japan introduced locomotor examinations for elementary school children. In this study, we conducted physical fitness tests and locomotor examinations to assess whether physical fitness is related to locomotor health.

Methods: We conducted physical fitness tests (8 items) and surveys on locomotor health status (7 items) among 259 girls and 309 boys. Then, we counted the number of children who required consultation with an orthopedic surgeon for a secondary examination.

Results: The physical fitness test results were normally distributed. According to the mean value, skewness, and kurtosis, we found no difference between these results and the distribution nationwide. The secondary examination was required in 39 (6.9%) children. A histogram of the physical fitness test results and the number of children requiring a secondary examination revealed no normal distribution, showing polarization between the peaks of the higher and lower parts of the physical fitness test results.

Conclusions: Those with low physical fitness test results and impaired locomotor health may be affected by obesity, and those with high physical fitness test results and impaired locomotor health may be musculoskeletal overused.

Therefore, it is necessary to consider appropriate interventions in the future.

Key words: 5th grade elementary school children, physical fitness test, locomotor examinations, overuse

Introduction

Since 1964, the Ministry of Education, Culture, Sports, Science, and Technology Japan (MEXT) has conducted the "Survey on Children's Physical Fitness and Athletic Ability". According to this, children's physical fitness and athletic ability peaked around 1985 and they have declined since then. The new physical fitness test, which was introduced in the 1999 survey on physical fitness and athletic ability, is based on changes in people's physiques, advances in sports medicine and science, and the aging of the population. It was adapted to the current situation. This new physical fitness test assesses athletic ability and conducts a questionnaire about lifestyle, such as sleeping hours and exercise habits. Exercise habits are closely related to children's physical fitness and athletic ability, and it has been reported that children with exercise habits have high physical fitness and athletic ability [1-4].

On the other hand, in April 2014, the Enforcement Regulations of the School Health and Safety Law were revised, and examination items for early detection of musculoskeletal diseases were added to the mandatory school medical examination items [5]. From April 1, 2016, the MEXT amended ordinances based on the School Health and Safety Law to add locomotor examinations to regular school health examinations. The additional items in the health questionnaire that has been used by each municipality since 2016 are, (1) the spine is bent, (2) there is pain when bending or arching the waist, and (3) there is pain in the upper extremities or where movement is difficult, (4) knee pain or poor movement, (5) inability to stand on one leg for more than 5 seconds, (6) inability to squat down, and (7) overall locomotor function including the walk. According to this survey, about 10% of children have impaired locomotor health [6].

In recent years, the number of fractures in childhood has increased, and the health of the locomotor system in children has also been impaired [7,8]. Boreham et al. found a relationship between childhood and adult health [9]. Therefore, an immature locomotor system and impaired locomotory health should be prevented or detected at an early stage to maintain the health of the locomotor system. However, to the best of our knowledge, little research has been done on the relationship between the results of the physical fitness test and locomotor examinations.

The purpose of this study was to investigate the relationship between children's physical fitness and locomotory health.

Materials and methods

Participants

With the cooperation of local governments, we recruited 5th graders from 5 municipal elementary schools in Nara Prefecture. This is because it is mandatory to submit the data of the 5th graders to the Prefectural Board of Education. As a result, we targeted a total of 568 children, 259 girls and 309 boys, who underwent all the evaluation items. Specifically, we included those who were 10 and 11 years old and measured their height and weight, as summarized in Table 1. Data were collected from 24 May to 7 June 2019.

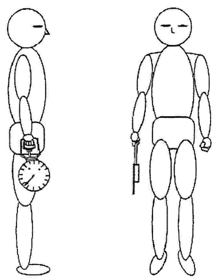
Because all study participants were minors at the time of the study, sufficient consideration was necessary regarding the release of the study participant data. Therefore, in response to a request by the Board of Education to review the study data, the data were provided to them after complete anonymization. The institutional review board of the relevant institution approved this study (H30-06).

Table 1. Characteristics of the participants

Sex	Age (years)	n	Height (cm)	Body wight (kg)	Average Laurel Index
Female	10	126	141.0 ± 7.3	34.3 ± 7.2	122.36 ± 4.88
	11	133	146.1 ± 7.0	38.2 ± 8.5	122.49 ± 7.64
Male	10	152	139.3 ± 5.7	34.5 ± 6.7	127.63 ± 7.51
	11	157	145.1 ± 7.2	37.7 ± 8.4	123.41 ± 7.09

Measurement

In the physical fitness tests, we used the new physical fitness test procedure of the MEXT and measured the following eight items: handgrip strength, upper body raising, long-seat forward bending, repeated side jump, 20 m shuttle run, 50 m run, standing width jump, and ball throwing [Fig. 1] [1]. The total score was used as the physical fitness index [Table 2] [1]. The phys-



Right lateral view Frontal view

Fig. 1-a. Handgrip strength

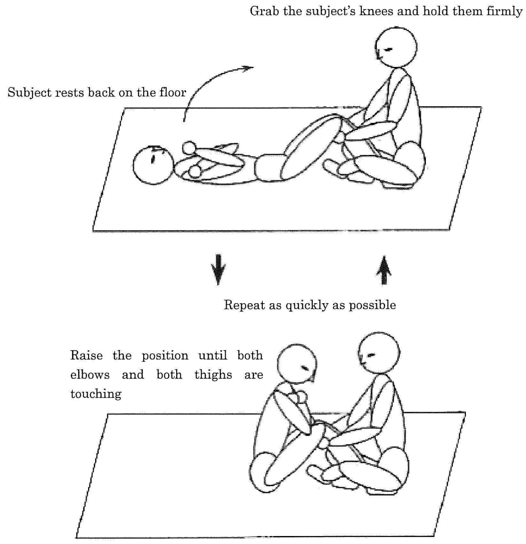


Fig. 1-b. Upper body raising

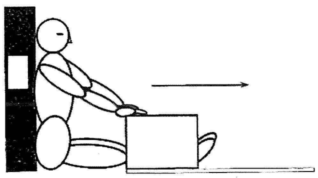


Fig. 1-c. Long - seat forward bending

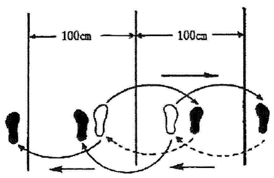


Fig. 1-d. Repeated side jump

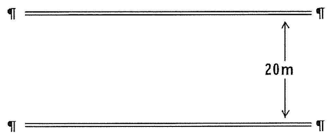


Fig. 1-e. 20 m shuttle run

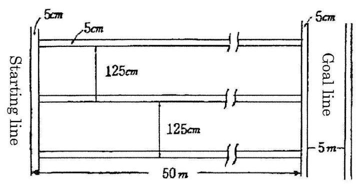


Fig. 1-f. 50 m run

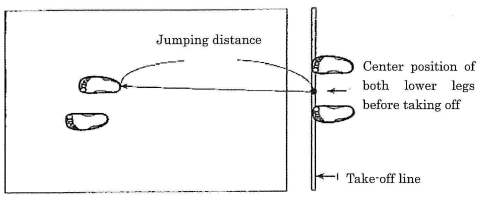


Fig. 1-g. Standing width jump

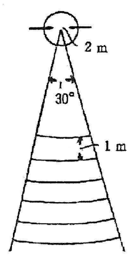


Fig. 1-h. Ball throwing

Table 2-a. Boys' score table by item

Points	Handgrip strength	Upper body raising	Long - seat forward bending	Repeated side jump	20 m shuttle run	50 m run	Standing width jump	Ball throwing
10	26 kg ≤	26 times ≤	49 cm ≤	50 points ≤	80 times ≤	≤ 8.0 seconds	192 cm ≤	40 m ≤
9	23 - 25	23 - 25	43 - 48	46 - 49	69 - 79	8.1 - 8.4	180 - 191	35 - 39
8	20 - 22	20 - 22	38 - 42	42 - 45	57 - 68	8.5 - 8.8	168 - 179	30 - 34
7	17 - 19	18 - 19	34 - 37	38 - 41	45 - 56	8.9 - 9.3	156 - 167	24 - 29
6	14 - 16	15 - 17	30 - 33	34 - 37	33 - 44	9.4 - 9.9	143 - 155	18 - 23
5	11 - 13	12 - 14	27 - 29	30 - 33	23 - 32	10.0 - 10.6	130 - 142	13 - 17
4	9 - 10	9 - 11	23 - 26	26 - 29	15 - 22	10.7 - 11.4	117 - 129	10 - 12
3	7 - 8	6 - 8	19 - 22	22 - 25	10 - 14	11.5 - 12.2	105 - 116	7 - 9
2	5 - 6	3 - 5	15 - 18	18 - 21	8 - 9	12.3 - 13.0	93 - 104	5 - 6
1	≤ 4 kg	≤ 2 times	≤ 14 cm	≤ 17 points	≤ 7 times	13.1 seconds ≤	≤ 92 cm	≤ 4 m

Table 2-b. Girls' score table by item

Points	Handgrip strength	Upper body raising	Long - seat forward bending	Repeated side jump	20 m shuttle run	50 m run	Standing width jump	Ball throwing
10	25 kg≤	23 times≤	52 cm≤	47 points≤	64 times≤	≤8.3 seconds	181 cm≤	25 m≤
9	22 - 24	20 - 22	46 - 51	43 - 46	54 - 63	8.4 - 8.7	170 - 180	21 - 24
8	19 - 21	18 - 19	41 - 45	40 - 42	44 - 53	8.8 - 9.1	160 - 169	17 - 20
7	16 - 18	16 - 17	37 - 40	36 - 39	35 - 43	9.2 - 9.6	147 - 159	14 - 16
6	13 - 15	14 - 15	33 - 36	32 - 35	26 - 34	9.7 - 10.2	134 - 146	11 - 13
5	11 - 12	12 - 13	29 - 32	28 - 31	19 - 25	10.3 - 10.9	121 - 133	8 - 10
4	9 - 10	9 - 11	25 - 28	25 - 27	14 - 18	11.0 - 11.6	109 - 120	6 - 7
3	7 - 8	6 - 8	21 - 24	21 - 24	10 - 13	11.7 - 12.4	98 - 108	5
2	4 - 6	3 - 5	18 - 20	17 - 20	8 - 9	12.5 - 13.2	85 - 97	4
1	≤3 kg	≤2 times	≤17 cm	≤16 points	≤7 times	13.3 seconds≤	≤84 cm	≤3 m

Table 3. Comprehensive Evaluation Criteria Table

Level	1st year grade	2nd year grade	3rd year grade	4th year grade	5th year grade	6th year grade
A	39 ≤	47 ≤	53 ≤	59 ≤	65 ≤	71 ≤
B	33〜38	41〜46	46〜52	52〜58	58〜64	63〜70
C	27〜32	34〜40	39〜45	45〜51	50〜57	55〜62
D	22〜26	27〜33	32〜38	38〜44	42〜49	46〜54
E	≤ 21	≤ 26	≤ 31	≤ 37	≤ 41	≤ 45

ical fitness index was a five-valued version of the results of each evaluation item established by the MEXT [Table 3] [1].

In assessing locomotor health, we used the locomotor examinations health questionnaire established by Bone and Joint Japan. This questionnaire comprised two items related to scoliosis and lower back pain, three items related to musculoskeletal disorders (pain, range of motion, and walking), one item related to hip disease and balance testing (standing on one leg), and one item related to flexibility (crouching test). The child's guardian answered the questionnaire, and the school physician judged whether the child needed to consult an orthopedic surgeon or not.

In addition, the Rohrer index was calculated as a numerical value to determine the developmental status of schoolchildren. This index is equivalent to the adult Body Mass Index (BMI) and is used to express the developmental status and degree of obesity in children. The index was calculated using the following formula.

Rohrer index score = Body Weight [kg] $\div$ Height [m]^3 $\times$ 10

Statistical analysis

We used the D'Agostino test as a normality test to observe the variation in the distribution of physical fitness test results among children requiring secondary examination in orthopedics. Subsequently, we calculated the skewness, kurtosis, and p-values. The significance level was set to less than 5%. Participants were classified into two groups according to the quality of the physical fitness test results (good or poor), and their Rohrer index values were compared using Student's *t*-test.

We used a histogram to graph the physical fitness test results. The histogram data was used to identify the physical fitness test results of the children requiring re-examination of their locomotor health.

Results

Figure 2 shows the distribution of physical fitness results according to the D'Agostino test. The results were normally distributed with p-value = 0.08, skewness = 0.87, and kurtosis = 2.25. The results also confirmed that there was no difference in distribution from the national physical fitness measurement results.

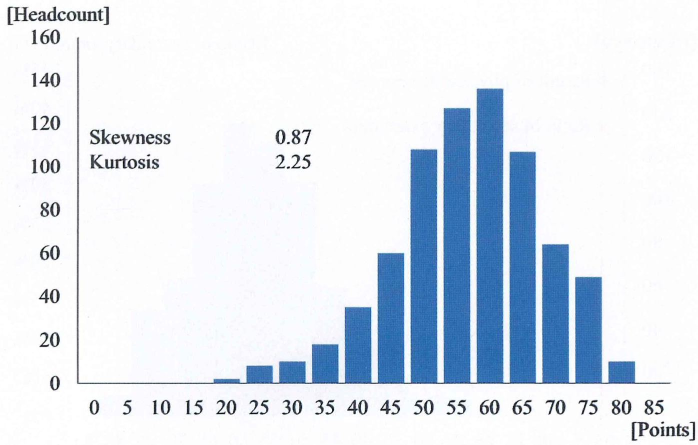


Fig. 2. Distribution of the physical fitness results
The results were p-value = 0.0776, skewness = 0.8660, and kurtosis = 2.2460, showing a normal distribution.

A total of 39 children needed a secondary examination, accounting for 6.9% of the total study population. Among these 39 cases, 20, 10, and 9 cases were related to scoliosis and lower back pain, flexibility (crouching test), and impaired locomotory health (pain, range of motion, and walking), respectively.

Figure 3 shows a histogram of the physical fitness test results (horizontal axis) and the number of children requiring a secondary examination (vertical axis). The D'Agostino test obtained a p-value <0.001, skewness = 2.13, and kurtosis = 6.67, indicating no normal distribution. Polarization was also observed between the lower and upper peaks in the fitness test results.

Figure 4 shows a histogram of the physical fitness test results (horizontal axis) and the per-

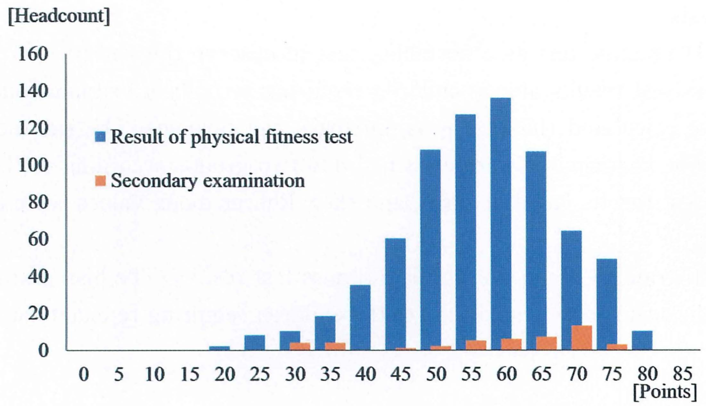


Fig. 3. Distribution of physical fitness results and children requiring secondary examination
This histogram shows the results of the sports test (horizontal axis) and the number of children requiring a secondary examination (vertical axis). The distribution of those requiring secondary examination was $p < 0.001$, skewness = 2.1349, and kurtosis = 6.6708 by the D'Agostino test, and no normal distribution was shown. There was a polarization between the peak in the lower part and the peak in the higher part of the sports test results.

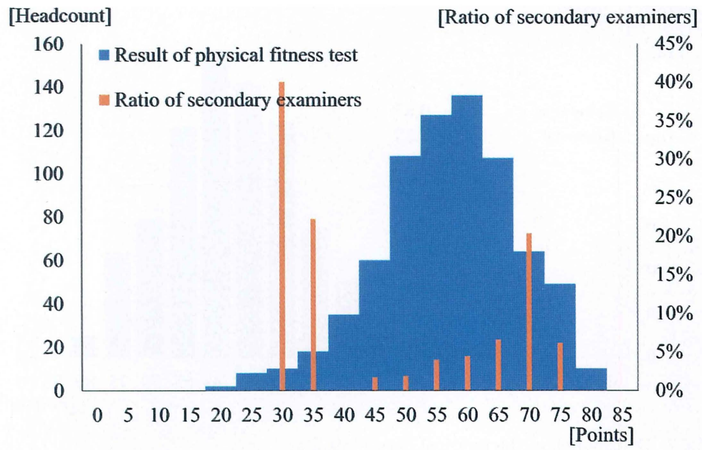


Fig. 4. Distribution of physical fitness results and percentage of children requiring secondary examination
This histogram shows the results of the sports test (horizontal axis) and the percentage of children requiring a secondary examination (vertical axis), giving a clearer picture of the polarization.

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Of the children requiring a secondary test, 16 with lower-than-average physical fitness test results had an average Rohrer index score of 129.5 (kg/m^3), and 23 with higher-than-average physical fitness test results had an average Rohrer index score of 121.5 (kg/m^3). Children with good physical fitness test results had a significantly lower Rohrer index score than those with poor physical fitness test results ($p < 0.01$). In addition, 8 children who had undergone orthopedic surgery were assessed, and their physical fitness test scores were the lowest.

Discussion

This cross-sectional study investigated the relationship between locomotor examination results and physical fitness tests in 10- to 11-year-old Japanese schoolchildren. Bimodal results were obtained for children who required a secondary examination by a school physician, with higher and lower physical fitness test results. This has not been reported previously.

In the results of this study, the Rohrer index was significantly higher in the group with low physical fitness test results. For children with low fitness levels, Raistenskis et al. stated that overweight and obese children are less active and have lower levels of fitness than those with normal weight [10]. Also, eight children with weak physical fitness tests had undergone orthopedic surgery, suggesting that those requiring secondary examinations may include children already undergoing treatment. As a future improvement, it will be important to investigate the correlation between fitness level and the Rohrer index.

Unfortunately, some of the children who performed well on the physical fitness tests required a secondary exam. There have been reports of locomotor disorders in childhood due to overuse[11,12], and it is possible that overuse is related, so early detection is desirable. This study explored the relationship between physical fitness and locomotor activity tests and revealed a bimodal pattern. In the future, appropriate intervention should be considered according to the results of physical fitness tests.

There was no substantial difference in distribution, skewness, and kurtosis between the physical fitness tests results of the present study and the results of the MEXT annual survey report on physical fitness, athletic ability, and exercise habits; similar to our study, it had a normal distribution, as reported by Nishijima et al. [13,14]. Although physical fitness differs depending on the region in Japan, this result seems to reflect the general domestic situation because of its similarity to the national average. The percentage of children requiring a secondary examination for locomotor function was not substantially different from the national results. Bone and Joint Japan reported that approximately 10% of the population has locomotor abnormalities. Tsushima et al. also reported that the estimated prevalence of locomotor disorders in Shimane and Miyazaki Prefectures was 6–10.2% [15]. The present results were consistent with those of previous studies. Cattuzzo et al. [16] investigated the relationship between motor competence (MC) and health-related physical fitness (HRPF) ratings and reported that there may be direct and indirect involvement between MC growth and HRPF rating from childhood to adulthood. Therefore, long-term observation of each child may provide useful data for observing changes in health status. Improving physical strength is crucial for health, and improvement at the expense of one side is meaningless. Physical activity and health in childhood are closely related to those in adulthood [17, 18]. Also, intense training in a single sport, at the exclusion of other sports, is recommended only in late adolescence to optimize success while minimizing injuries, psychological stress, and burnout [19]. It has been reported that intense training needs to be delayed until early adulthood. Numerous children enjoy physical activities, which are ideal for physical strength improvement, but children should refrain from extraneous activities that may debilitate their locomotor skills.

This study had several limitations. The study design was cross-sectional. In addition, this time, the locomotor examinations were checked using a questionnaire prepared by Bone and Joint Japan, and the school physician decided whether or not to have a secondary examination. A school physician is not necessarily an orthopedic surgeon. Therefore, these examinations check locomotorium health and do not diagnose orthopedic disease.

We found a bimodal distribution of children requiring secondary screening by combining physical fitness tests and locomotor examination results. This is very significant. Even if the health of the locomotor system is impaired, the cause may differ depending on the results of the physical fitness test, so the response will also differ. Thus, longitudinal studies with relevant interventions are warranted in the future. We would like to develop it into a longitudinal study with better interventions in the future.

Conclusions

This cross-sectional study investigated the relationship between the results of locomotor examinations and physical fitness testing in Japanese school children aged 10–11 years. The proportion of children requiring secondary examinations at the discretion of the school physician was 6.9%. Both good and poor physical fitness test results were obtained for children requiring a secondary examination by an orthopedist. Children with a low physical fitness test score and a locomotor disability also had a medical examination history. In this population, overall, musculoskeletal overuse may be the cause of the musculoskeletal disorders observed among those with high physical fitness test scores. In the future, we would like to examine appropriate intervention methods for both groups.

Declaration of competing interest

None.

Acknowledgements

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