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# Does the Record of Physical Fitness Tests Reveal Locomotor Disorders in Children? Relationship Between Records of Physical Fitness Tests and Locomotor Disorder Screenings: Results in Japanese Children

Syuro Ito [1, 2, *], Takahiko Fukumoto [2], Hidetaka Imagita [3], Kazuyuki Tabira [2]

[1] Sakai Municipal Mukogaoka Elementary School, Sakai city, Osaka Prefecture, Japan
[2] Kio University, Koryo-cho, Kitakatsuragi-gun, Nara Prefecture, Japan
[3] Saitama Prefectural University, Koshigaya city, Sasitama Prefecture, Japan

[*] *Corresponding author:* Sakai Municipal Mukogaoka Elementary School, Sakai city, Osaka Prefecture, Japan. Email: ito-s@sakai.ed.jp

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## Abstract

**Background:** In Japan, children often suffer from locomotor disorders due to either too much or too little physical activity. As a result, locomotive examinations have been incorporated into Japanese school education. However, the first stage of the examination process is based on a screening questionnaire by parents, which may lead to serious oversights. Researchers discovered that considering the results of locomotive examinations along with the results of physical fitness tests can lead to early detection of locomotor disorders in children without overlooking them.

**Objectives:** This study clarified the relationship between fitness test results and locomotor disorder screenings, highlighting the possibility of early detection of these disorders.

**Methods:** This is a retrospective study in which we examined the results of locomotor disorder screenings and physical fitness tests of 315 elementary students in Japan in 2022 by gender and grade. Furthermore, we analyzed whether physical fitness test scores differed between children whose screenings did or did not indicate abnormalities, also categorized by gender and grade.

**Results:** Results showed the following statistical outcomes. Overall, we found slightly significant differences between boys in the two groups in the third and fourth grades and a significant difference at 0.1% - 1% in sit-up scores between the two groups of boys in both grades. Grip strength also showed significant differences in the third and fifth grades at 1% and 5%, respectively. The fourth-grade boys showed significant differences in the seated forward bend and side-steer scores at 1% and 5%, respectively. Moreover, there were significant differences between children with and without abnormalities in their 50-m run scores among boys in the third and fourth grades and girls in the fourth grade. There was also a significant difference of 0.1% - 1% in the standing long jump scores between the groups of fourth- and sixth-grade boys. Thus, an association was found between the results of the screening of locomotive examinations and the results of the physical fitness test.

**Conclusions:** Combining fitness tests and locomotor disorder screenings may enable early detection and prevention of locomotor disorders in children.

*Keywords:* World Health Organization, Children, Physical Therapist, Japan, Elementary Students, Locomotor Disorder, Screening, Physical Fitness test, Instantaneous Power, Bone and Joint

## 1. Background

Regular exercise and other health-promoting activities benefit physical and mental health (1). However, the COVID-19 pandemic limited the times and places where children could be active; sports and daily activities were restricted, leading to a decline in children's physical fitness (2, 3). Notably, even before the COVID-19 pandemic, a sizable percentage of Japanese children did not exercise regularly. According to a survey of exercise habits conducted by the Japanese Ministry of Education, Culture, Sports, Science, and Technology in 2019 (4, 5), about 20% of junior high school students (girls) exercised less than 60 minutes a week (excluding time spent in physical education classes), and nearly half of them did not exercise at all

(4, 5). This lack of exercise can contribute to conditions such as obesity and childhood locomotive syndrome (6-8). Indeed, childhood obesity is a problem in many industrialized countries (6).

In addition to disorders caused by insufficient exercise, excessive exercise can also lead to physical and mental illness, including locomotor disorders (9-14). As with obesity, locomotor disorders are a global problem, and in 2000, the World Health Organization declared 2000 – 2010 as the Bone and Joint Decade (15, 16). Locomotor disorders include osteoporosis, osteoarthritis, rheumatism, sports injuries, and limb injuries. Among these, osteoarthritis and sports injuries are the most common locomotor disorders among children (15). Particularly, overuse syndrome, caused by overexercising, is an issue. Locomotor disorders are a cause for great concern because they can hinder normal growth and decrease future quality of life.

In fact, "overuse syndrome" has been recognized in Japan for quite some time. In 1911, playing too much baseball while growing up was not recommended (17). Furthermore, in the same era, the importance of building physical strength among young people was also debated (17), and the relationship between the healthy development of the body and the importance of building physical strength could be said to be an "old and new issue."

Therefore, beginning in 2016, parents in Japan were asked to complete a screening questionnaire to check for potential locomotor disorders in children enrolled in compulsory education schools. This initiative aimed to enable early detection of locomotor disorders in children, corresponding to the bone and joint decade movement (16, 18, 19). However, parental screening has been considered insufficient in identifying all potential disorders, posing a challenge. Moreover, there are few systematic reports on locomotive examinations in children (16, 18, 19).

Improving screening accuracy is highly desirable.

Conversely, children's physical fitness tests are conducted every year in Japanese schools. These are large-scale surveys targeting children across Japan, consisting of eight types of tests to measure muscle strength, endurance, and other physical attributes (4). Staying fit is important, and regular exercise and other health-promoting activities benefit physical and mental health, contributing to overall happiness (1). Additionally, physical fitness, or the intake and release of energy, is closely related to all aspects of growing children. For instance, breakfast and snack intake may affect cognitive function, academic performance, and physical activity in adolescents (20). Physical fitness tests not only assess physical education results but are also important for understanding physical and mental health.

We propose that children's physical fitness test scores might help identify potential abnormalities in their locomotor systems, allowing for earlier and more accurate diagnoses.

## 2. Objectives

The purpose of this study was to clarify the relationship between the results of physical fitness tests and those of locomotor examinations and to investigate the possibility of early detection of locomotor disorders in children. Following the COVID-19 pandemic, it is necessary to carefully monitor the condition of children's locomotive organs and provide appropriate and safe exercise programs (16, 18, 19, 21).

## 3. Methods

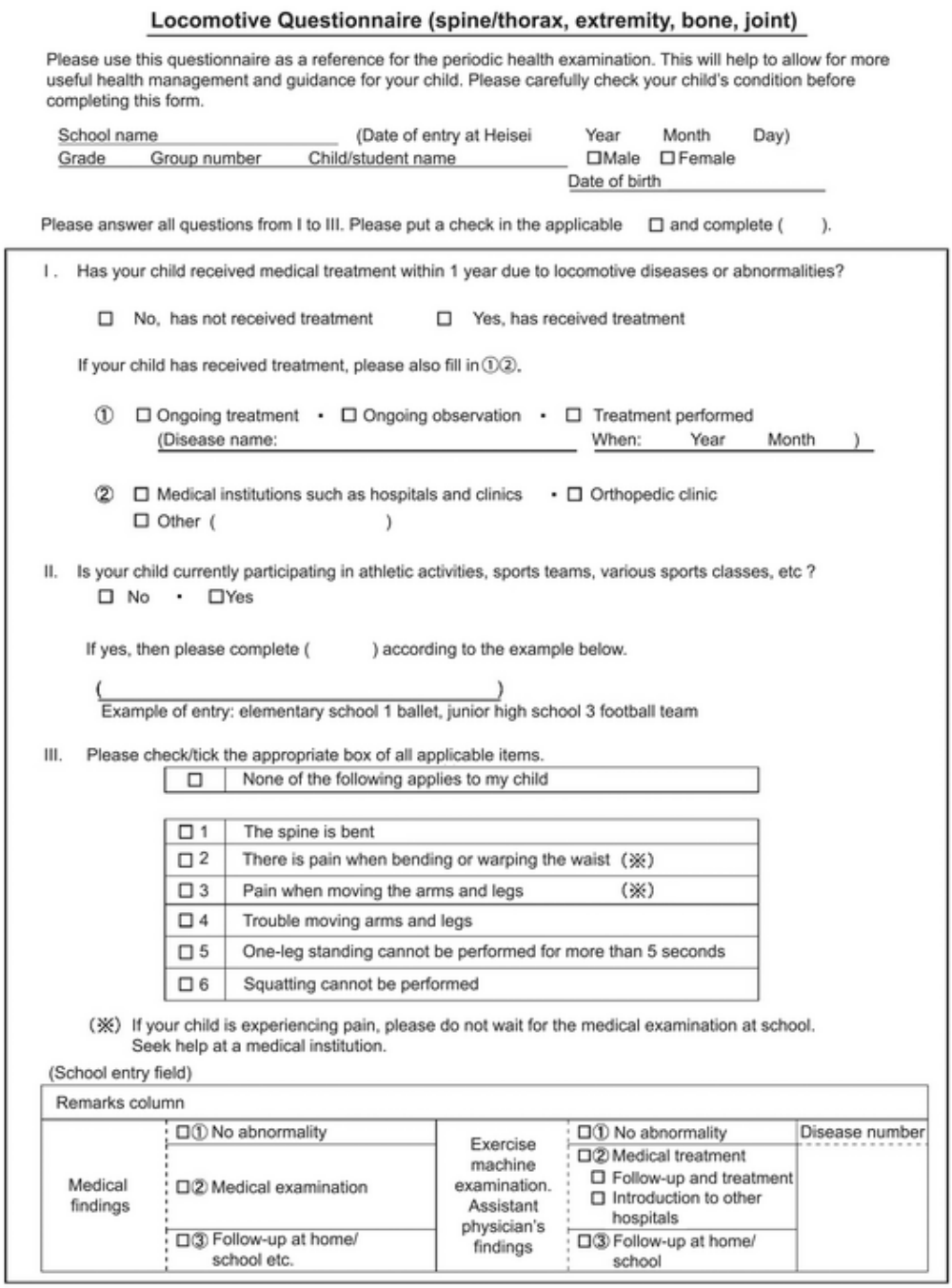
### 3.1. Participants

The study sample included 315 third- to sixth-grade children (aged 8 – 12 years) from one elementary school in Osaka Prefecture in 2022. Children with physical disabilities were excluded. Data were collected from the locomotor disorder examinations and physical fitness tests held at schools. This epidemiological study used a retrospective design. The school in this study is a public school with fixed attendance zones, located in an urban residential area, and composed of a relatively uniform student population.

### 3.2. Instrumentation

#### 3.2.1. Locomotor Disorder Examination

In 2016, Japanese elementary schools began administering structured questionnaires to parents and guardians to assess their children's motor functioning and identify latent abnormalities. School authorities collect the results each year. The questionnaire is based on survey results from public interest foundations such as Bone and Joint Japan and the Japanese Association of



**Locomotive Questionnaire (spine/thorax, extremity, bone, joint)**

Please use this questionnaire as a reference for the periodic health examination. This will help to allow for more useful health management and guidance for your child. Please carefully check your child's condition before completing this form.

School name (Date of entry at Heisei Year Month Day)
Grade Group number Child/student name ☐Male ☐Female
Date of birth

Please answer all questions from I to III. Please put a check in the applicable ☐ and complete ( ).

I. Has your child received medical treatment within 1 year due to locomotive diseases or abnormalities?

☐ No, has not received treatment ☐ Yes, has received treatment

If your child has received treatment, please also fill in①②.

① ☐ Ongoing treatment • ☐ Ongoing observation • ☐ Treatment performed
(Disease name: When: Year Month )

② ☐ Medical institutions such as hospitals and clinics • ☐ Orthopedic clinic
☐ Other ( )

II. Is your child currently participating in athletic activities, sports teams, various sports classes, etc ?

☐ No • ☐Yes

If yes, then please complete ( ) according to the example below.

( )
Example of entry: elementary school 1 ballet, junior high school 3 football team

III. Please check/tick the appropriate box of all applicable items.

| | |
|---|---|
| ☐ | None of the following applies to my child |

| | |
|---|---|
| ☐ 1 | The spine is bent |
| ☐ 2 | There is pain when bending or warping the waist (※) |
| ☐ 3 | Pain when moving the arms and legs (※) |
| ☐ 4 | Trouble moving arms and legs |
| ☐ 5 | One-leg standing cannot be performed for more than 5 seconds |
| ☐ 6 | Squatting cannot be performed |

(※) If your child is experiencing pain, please do not wait for the medical examination at school. Seek help at a medical institution.

(School entry field)

| Remarks column | | | | |
|---|---|---|---|---|
| Medical findings | ☐① No abnormality | Exercise machine examination. Assistant physician's findings | ☐① No abnormality | Disease number |
| | ☐② Medical examination | | ☐② Medical treatment ☐ Follow-up and treatment ☐ Introduction to other hospitals | |
| | ☐③ Follow-up at home/ school etc. | | ☐③ Follow-up at home/ school | |

**Figure 1.** Questionnaire about locomotorium (spine/thorax, extremity, bone joint) used in Osaka Prefecture

School Health. It serves as a method for locomotor assessment that can be completed quickly and efficiently by parents, guardians, or school nurses not specialized in the field (Figure 1, Appendix 1) (16, 18, 19, 22). These exams occur during April and May. A child is first diagnosed by a school physician only if a parent

**Table 1.** Number of Participating Children and Number of Children with Locomotor Disorders Reported in the Screening by Grade (2022, Unit: Children)

| Variables | Total Number of Participants | Number of Children Whose Parents/Guardians Confirmed the Risk of Locomotior Disorder (Number of Children with Reported Abnormalities in the Screening) | Number of Children Whose Parents/Guardians Confirmed the Risk of Locomotor Disorder (Excluding Children Whose Score in the Physical Fitness Tests Was Over 2 SD Greater Than the Mean) |
|---|---|---|---|
| **3rd grade** | | | |
| Boys | **44** | **4** | **4** |
| Girls | **31** | **0** | **0** |
| **4th grade** | | | |
| Boys | **38** | **5** | **5** |
| Girls | **42** | **4** | **3** |
| **5th grade** | | | |
| Boys | **49** | **3** | **3** |
| Girls | **35** | **0** | **0** |
| **6th grade** | | | |
| Boys | **35** | **6** | **4** |
| Girls | **41** | **0** | **0** |
| **Total** | | | |
| (Boys and girls) | **315** | **22** | **19** |

indicates that the child's locomotor systems are in an abnormal state in the screening questionnaire. Upon diagnosis, if the school physician believes there is an abnormality, the child will be examined and treated by a specialist. This study focuses on children who were identified as "abnormal" in the screening questionnaire.

### 3.3. Physical Fitness Test

Elementary school students in Japan also undergo annual physical fitness testing based on tests established by the Japan Sports Agency (4, 23). These tests include grip strength (for measuring muscle strength), sit-ups (for measuring muscle endurance), trunk forward flexion (also known as sitting trunk flexion, for measuring flexibility), side-step (for measuring agility), 20-m shuttle run (for measuring cardiopulmonary endurance), 50-m run (for measuring instantaneous power), standing long jump (for measuring instantaneous power), and softball throw (for measuring instantaneous movement). The physical fitness tests are administered from the end of May to mid-June, making it unlikely that children's physical development would have significantly advanced between the two testing periods.

For details on the implementation method, please see Reference 24 (24).

These records are securely kept at the school and returned to all children. Meanwhile, the records of fifth graders are submitted to the Ministry of Education, Culture, Sports, Science and Technology and are used in statistics as national data.

### 3.4. Procedure

We calculated the number of students showing symptoms during the locomotor disorder screening for each grade. Then, we compared the physical fitness test results and locomotion screening results in the 19 children identified through the screening as having a possible locomotor disorder. For the protocol of this study, see Appendix 2.

### 3.5. Data Analysis

After aggregating the 2022 physical fitness test results for the 315 students by grade and sex, we divided the children into two groups: Those who did and did not show signs of locomotor abnormalities according to their parents' questionnaire ratings. We then analyzed whether there were differences in the two groups' physical fitness scores. Next, we used unpaired *t*-tests to compare the individual fitness test scores for each event by grade and sex between the groups.

Among the 22 children whose parents identified a risk of locomotor disorders, children with extremely high physical fitness test scores [more than two standard deviations (SD) above the grade mean] were excluded as possible outliers (the exclusion criteria also

consider the child's daily situation). We conducted the statistical analysis using Bell Curve for Windows (Ekuseru-Tokei) version 4.01 (Social Survey Research Information Co., Ltd, Japan).

### 3.6. Ethical Considerations

Data obtained from locomotor disorder screenings and physical fitness tests were completely anonymous and were not associated with any other data. The fully anonymized data were securely stored in the archives of the children's elementary school. Furthermore, approval was obtained from the supervisor for data collection, and this study was conducted with approval from the ethics review committee Kio University.

## 4. Results

### 4.1. Locomotor Disorder Screening Results

Parents did not report any abnormalities in the locomotion of third-, fifth-, or sixth-grade girls (Table 1). Appendix 3 lists the symptoms for each grade (third to sixth) in 2022 for the 22 students whose parent-rated screening evaluations indicated symptoms of abnormalities. Six children complained of a bend in the spine (including scoliosis), and nine children complained of an inability to crouch down. One child complained of pain, while some exhibited multiple symptoms.

Of the 22 children listed in Appendix 3 and Table 1, all were considered to require further observation and possible treatment by a physician.

Three children had physical fitness test scores that were two standard deviations above the mean for each grade, and we excluded these as possible outliers.

### 4.2. Physical Fitness Test Results

Appendix 4 shows the results of the 2022 physical fitness tests for the 315 students in this study, categorized by grade and sex. When comparing students of the same grade, boys generally have better records, and their records improve as the grade progresses.

Table 2 and Appendix 5 show the *t*-test results for boys and girls for each grade and physical fitness event. The results reveal that fourth-grade boys showed the most significant differences in physical fitness test scores between the groups with and without abnormalities on screening. There were slightly significant differences overall between boys in the two groups in the third and fourth grades, as well as a significant difference of 0.1% – 1% in sit-up scores between the two groups of boys in both grades. Grip strength also showed significant differences in the third and fifth grades at 1% and 5%, respectively. The fourth-grade boys also showed significant differences in the seated forward bend and side-steer scores at 1% and 5%, respectively.

In addition, there were significant differences between children with and without abnormalities in their 50-m run scores among boys in the third and fourth grades and girls in the fourth grade. There was also a significant difference of 0.1% – 1% in the standing long jump scores between the groups of fourth-grade and sixth-grade boys.

In the 2022 locomotor organ check-up at this elementary school, parents did not report any abnormal conditions in their children's locomotor organs for girls in the 3rd, 5th, and 6th grades.

## 5. Discussion

In this study, it was difficult to determine which symptoms affected which physical fitness test scores. However, the *t*-test results for the fourth- to sixth-graders (boys and girls) showed significantly lower scores for events such as the 50-m run and standing long jump among many of the children whose parents reported possible abnormalities in the screening. Many parents of children across all grades identified the inability to crouch and a bend in the spine as abnormalities their children exhibited, and these conditions have been shown to affect performance in exercises requiring instantaneous power (18). Separately, in a recent longitudinal study of elementary and junior high school students in Japan, Tomaru et al. (19) found ankle stiffness and an inability to squat to be risk factors for ankle sprains.

Fourth-grade boys reported by their parents as possibly having locomotor abnormalities according to locomotor disorder screening had significantly lower softball throw scores, which measure upper-body explosive power, compared to children without locomotor abnormalities (Refer to Table 2, Appendix 5, Boys' softball records). Throwing a softball is a complex motor task involving numerous skills (25, 26). Generally,

**Table 2.** Results of the *t*-test Between the Group in Which Parents Reported that Their Child's Locomotive Condition Was Abnormal in the Locomotive Examination and the Group in Which There Was No Abnormality (by Grade, Sport, and Sex) (Simplified version)

| Grade, Boys | Grip Strength | Sit-ups | Trunk Forward Flexion | Side-Step |
|---|---|---|---|---|
| | P-Value | P-Value | P-Value | P-Value |
| 3rd | P < 0.01 | P < 0.001 | 0.1696 | 0.1647 |
| 4th | 0.2729 | P < 0.01 | P < 0.01 | P < 0.05 |
| 5th | P < 0.05 | 0.6286 | 0.5067 | 0.7201 |
| 6th | 0.9862 | 0.2782 | 0.7692 | 0.3977 |
| Grade, boys | 20-m shuttle run | 50-m run | Standing long jump | Softball throw |
| | P-value | P-value | P-value | P-value |
| 3rd | 0.3575 | P < 0.01 | 0.1935 | 0.7338 |
| 4th | 0.1513 | P < 0.05 | P < 0.001 | P < 0.01 |
| 5th | 0.2595 | 0.3659 | 0.500 | 0.2877 |
| 6th | 0.3047 | 0.2164 | P < 0.01 | 0.8339 |
| Grade, girls | Grip strength | Sit-ups | Trunk forward flexion | Side-step |
| | P-value | P-value | P-value | P-value |
| 3rd | — | — | — | — |
| 4th | 0.1281 | 0.2505 | 0.2037 | 0.2481 |
| 5th | — | — | — | — |
| 6th | — | — | — | — |
| Grade, girls | 20-m shuttle run | 50-m run | Standing long jump | Softball throw |
| | P-value | P-value | P-value | P-value |
| 3rd | — | — | — | — |
| 4th | 0.69 | P < 0.05 | 0.2187 | 0.4352 |
| 5th | — | — | — | — |
| 6th | — | — | — | — |

experienced children tend to throw well (25, 26). This result may indicate performance differences due to some condition, excluding the effects of experience. Additionally, parents of three fourth-graders noted a bend in the spine, which may affect the softball throw. Furthermore, third- and fifth-grade boys, whose muscle strength is actively developing, showed significant differences in grip strength between those whose parents did and did not report symptoms suggesting locomotor disorders (Refer to Table 2, Appendix 5).

The proportion of girls reporting abnormalities during screening was low (4 out of 22). Although the reason is unclear, there are reports that boys are more likely to suffer from overuse syndrome (27).

Among the children who reported "abnormalities" in this study, 8 participated in swimming, 2 played rugby, 1 did karate, 1 was a cheerleader, 1 played basketball, and 3 played softball and baseball. It can be observed that 16 of the 22 children who reported "abnormalities" were engaged in some type of exercise outside of school. This percentage is higher than the average. However, no association was found between exercise outside of school and screening results.

In Japan, in addition to physical education classes at school, many children participate in sports like swimming, basketball, softball, baseball, judo, and kendo after school and during holidays. Particularly, "overuse syndrome" is suspected when symptoms are accompanied by pain in the shoulders and elbows (27). However, in this study, one child experiencing pain was ultimately diagnosed by doctors as having no abnormality. If the body is in pain, it is natural that one will not be able to perform to the fullest during exercise. Conversely, if scoliosis is the cause of a curved spine, the cause is currently unclear (28). In fact, among the children who reported that their spines are curved, several attend swimming schools. However, the relationship between swimming and spinal curvature is unclear, and the consequences of a "curved spine" on athletic performance are unknown. Moreover, if a child is unable to squat, it could be due to bones, muscles, tendons, and ligaments growing at different rates, or a

lack of flexibility in the hip and ankle joints (29). If children are not flexible, they may need to reevaluate their lifestyle habits. Conditions such as long screen time, lethargy, and overnutrition may also impact locomotor disorders. The relationship between growth, exercise experience, physical fitness test records, and locomotor disorders will need to be clarified in the future.

Among the elementary school students whose survey data were used in this study, 2.8%, 5.3%, and 7.0% of the children's parents reported movement disorders in 2016, 2018, and 2022, respectively (18). These percentages are all lower than the common statistics in Japan, and the proportion of children whom school physicians deemed needed treatment was even lower (30, 31). Because the prevalence of locomotor disorders is commonly estimated at 10%, some participants may have children with underlying movement disorders (30, 31).

Schools are recommended to coordinate with their school doctor or physical therapist to evaluate children's physical fitness test records. Furthermore, children whose physical fitness test records are below a threshold level may suffer from locomotor disorders in the future (18).

### 5.1. Implications for Practice

According to Bone and Joint Japan, "One of the most common physical complaints that Japanese people have is due to locomotor organ disorders" (15). The locomotor organs are of particular interest in childhood. The results of this study showed significant differences in the physical fitness test results between children whose parents reported locomotor abnormalities and those who did not, consistent with findings from previous studies (18).

This study also demonstrated that physical fitness test records may be significantly worse if the locomotor system is reported to be in an abnormal state (i.e., locomotive examination screening is effective in detecting locomotor disorders). When the sample size is small, as in this study, there is a risk of increasing false negative results. Therefore, the number of children with locomotor organ abnormalities and locomotor disorders may actually be even higher. To this end, the possibility of early detection of locomotor disorders may increase if a physical fitness test is also used in conjunction with the locomotor system examination screening test.

As a result, it may be possible to identify issues with a child's body if their physical fitness test record falls below a certain level.

### 5.2. Limitations

In this study, we did not aim to establish how individual symptoms might affect performance on physical skills tests. We believe that the accuracy of the findings of this study will increase by expanding the number of parameters and conducting prospective studies. If the sample size is small, the false negative rate increases and accuracy decreases (32). Due to the small sample size of this study, a larger investigation is required. It is also necessary to consider the differences in the general prevalence of locomotor disorders between boys and girls.

Additionally, this study was unable to determine which types of physical fitness tests children with specific symptoms were weaker in. This needs to be clarified in the future.

Incidentally, in this study, we only considered the relationship between the results of physical fitness tests and the results of screening for locomotor disorders. Therefore, it is not possible to consider factors affecting physical health, such as children's nutritional status, psychological health status, and socio-economic background, on locomotor disorders. Future research should take a comprehensive view of the entire environment surrounding children to better understand factors affecting their healthy growth.

### 5.3. Conclusions

Investigations combining the results of locomotor screenings and physical fitness tests may enable early detection and prevention of locomotor disorders in children. This approach also has the potential to enhance our understanding of the relationship between children's physical abilities and their motor organs, contributing to safer and more effective exercise practices.

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## Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

## Footnotes

**Authors' Contribution:** Conceptualization, S.I. and T.F.; methodology, S.I.; software, S.I.; validation, T.F., H.I.; formal analysis, S.I.; investigation, S.I.; resources, T.F. and S.I.; data curation, S.I.; writing—original draft preparation, S.I.; writing—review and editing, S.I.; visualization, S.I.; supervision, K.T.; project administration, S.I. and T.F.; and funding acquisition, none. All authors have read and agreed to the published version of the manuscript.

**Conflict of Interests Statement:** The authors declare that there is no conflict of interest.

**Data Availability:** The data sets generated and analyzed during the current study are not publicly available for privacy reasons but are available from the corresponding author upon reasonable request.

**Ethical Approval:** This study was conducted with approval from the ethics review committee Kio University Graduate School of Health Sciences Ethics Review Committee (Approval Number-H28-06) and Sakai City Elementary School Physical Education Research Association Ethics Review Committee.

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