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Changes in Children's Physical Fitness Following the COVID-19 Pandemic: A Retrospective Study

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Abstract

Background: Due to the impact of coronavirus disease 2019 (COVID-19), all schools in Japan were closed in March 2020, including those providing compulsory education. They remained closed for up to 3 months.

Objectives: Researchers investigated the difference in children's physical fitness results before and after the spring of 2020, during which time Japanese schools were closed and fitness opportunities were limited.

Methods: Researchers compared the athletic performances of Japanese elementary school children before and after the COVID-19 pandemic (2014 and 2022 - 2023, respectively). This was a retrospective epidemiological study of 438 students between the ages of 8 and 10 years old at Elementary School A in Osaka Prefecture. Researchers used an unpaired *t*-test to investigate whether significant differences occurred according to grade, sex, and activity.

Results: Results showed that in physical fitness exams for third- and fourth-grade children, the athletic performances of children in 2022 and 2023 significantly declined in all examined activities other than the trunk forward flexion and the 50-m run, compared with children in the same grade in 2014. In the 20-m shuttle run, there was a significant difference at the $P < 0.01$ level for fourth-grade boys and girls and a significant difference at the $P < 0.05$ level for those in third grade. In 2023, improvements were seen in explosive exercises. Following the self-restraint period during the COVID-19 pandemic, the 2022 and 2023 physical fitness exam results were substantially inferior in several aspects, compared with the results from similar exams conducted in 2014. Notably, muscle endurance and general endurance had significantly decreased.

Conclusions: Because the muscle endurance and general endurance of elementary school students were heavily impacted, sufficient caution is required when resuming physical education activities in the future. It is therefore necessary to teach students how to exercise safely using a detailed exercise program.

Keywords: COVID-19, Elementary School Students, Physical Fitness Test, Athletic Performance, Japan

1. Background

There has been an unprecedented surge in sports and health in Japan. This trend is encouraging for adults and children representing our future because engaging in physical exercise and health-related activities offers substantially extended physical and mental benefits (1). However, coronavirus disease 2019 (COVID-19) restrictions have been placed on the space and time of children's activities since 2020, fundamentally changing children's lifestyles (2). In Japan, all schools were closed for approximately 3 months from March 2, 2020, including those providing compulsory education, reducing students' opportunities for physical activity (3-7). This study has therefore assumed a difference in children's physical strength before and after the spring of 2020 when COVID-19 restrictions were put into place.

Proper exercise and physical fitness are key factors for promoting an active and healthy lifestyle in children. Therefore, the decline in children's motor skills and physical strength could pose a major threat to public health in the future (8). Physical activity in schoolchildren is associated with cognitive development and is essential for developing their

nervous systems, and physical training improves coordination, orientation, laterality, and organization (9). As Barnett et al. have argued, "Motor skill development should be a key strategy in childhood interventions aiming to promote long-term physical activity" (10).

In Japan, COVID-19 infection prevention strategies have had a variety of impacts, including in school sports activities (11, 12). Amagasa et al. conducted a descriptive epidemiological study examining the impacts of the pandemic on physical activity, finding that medium- and vigorous-intensity physical activity decreased across age groups in Japan and overseas (11). In Japanese physical education, "exercises where children are crowded together" and "exercises where students grapple or come into contact with each other at close range" were disallowed (12). Sports activities gradually resumed from 2022, and the ban on sporting events was completely lifted in May 2023.

As a result of the above interruptions to physical education, the Japan Sports Agency acknowledged that the rate of children's exercise has declined based on a 2021 survey of the athletic abilities of elementary and junior high school students in Japan. In the cross-tabulation, there was also an overall "increase in obesity", which could be attributed to the increase in sedentary activities (e.g., an increase in the time spent looking at smartphones) (13). Although the survey results presented average increases and decreases, there was no indication of whether these were significantly different from prepandemic averages.

2. Objectives

This study therefore explored children's current physical abilities in the aftermath of the COVID-19 pandemic. To do so, physical education test results from 2014 (prepandemic), 2022, and 2023 (postpandemic) were compared to investigate the extent of the changes. This study used these findings to predict future needs in physical education and discuss the requirements for promoting the continued healthy development of children's mental and physical health.

3. Methods

3.1. Study Design and Participants

This was a retrospective epidemiological study of 438 students aged 8 - 10 years at Elementary School A in Osaka Prefecture. Researchers compared the 2014 data of 44 boys and 47 girls in the third grade (aged 8 - 9 years) and 47 boys and 52 girls in the fourth grade (aged 9 - 10 years) with the 2022 - 2023 data of 44 boys and 31 girls in the third grade and 38 boys and 42 girls in the fourth grade. In addition, in 2023, data on 43 third-year boys and 50 third-year girls was added. The number of subjects is the number of students enrolled in that grade.

3.2. Ethical Considerations

The obtained data comprised the results of exercise examinations and physical fitness test data from annual events related to health and physical education and were completely anonymous. Owing to the retrospective nature of the study, informed consent was not required. However, this research was conducted with the consent of the Principal of Elementary School A, and ethical approval was obtained from Research Ethics Committee of Kio University (No. H28-06) and the Sakai City Association of Principals of Municipal Schools (No. sktm-1). This study was conducted in accordance with the Declaration of Helsinki.

3.3. Physical Fitness Exams

In 2014, 2022, and 2023, the third- and fourth-grade students of Elementary School A underwent physical fitness exams according to the methods stipulated by the Japan Sports Agency (3, 14). Measurements were taken by experienced physical education teachers. Grip strength (a muscle strength activity) was measured. Other activities included sit-ups (muscle endurance), trunk forward flexions (flexibility), side steps (agility), a 20-m shuttle run (cardiopulmonary endurance), a 50-m run (instantaneous power), standing long jumps (instantaneous power), and softball throws (instantaneous movement) (14). For detailed information about the physical fitness tests, refer to reference 14 or Appendix 1 in Supplementary File. These records are kept securely at the school, and all children receive copies of their results. In addition, the records for fifth graders are submitted to Japan's Ministry of Education, Culture, Sports, Science and Technology and are used for national statistics.

3.4. Analysis

Researchers compared the 2014, 2022, and 2023 physical fitness data of third- and fourth-grade students at Elementary School A in Osaka Prefecture. The 2014 data was selected as the representative data for the prepandemic period. This was because the Rohrer's

Table 1. Rohrer's Index of Third- and Fourth-Grade Students, 2014, 2022, and 2023

Years	Third-Grade Boys	Third-Grade Girls	Fourth-Grade Boys	Fourth-Grade Girls
2014	125.9	123.5	123.8	122.1
2022	126.1	123.2	124.1	122.3
2023	128.4	128.8	134.1	126.7

Index results, which may influence children's athletic performance and is widely used in Japan to classify children's body types (corpulent, normal, or lean) (15), were similar to those of the third- and fourth-grade students in 2022 and 2023. Children's athletic abilities are influenced by various factors. To minimize such factors and ensure the comparability of results, we analyzed the athletic performance of groups with similar body types (Table 1). Note that this study was unable to account for factors such as screen time, the number and type of extracurricular activities, height, weight, and the home environment.

Researchers used an unpaired *t*-test by grade and sex to investigate whether the physical fitness tests exhibited significant differences in grade and activity. Considerably, this method was the most effective for determining differences in physical fitness records between the two samples: Children in 2014, 2022, and 2023 (16). The unpaired *t*-test was still determined to be the best method, as modeled by a similar previous study (17). Statistical analysis was performed using BellCurve for Windows version 4.01 (Microsoft Excel for Windows®, Social Survey Research Information Co., Ltd.).

4. Results

The results of the 2014 and 2022 physical fitness exams are shown in Table 2. Overall, simple comparisons of the mean figures showed that the 2022 exam results were inferior to those of 2014 for boys and girls in both grades. Severe drops were observed in the muscle and cardiopulmonary endurance activities, such as sit-ups and the 20-m shuttle run. Depending on the activity, the 2022 results were typically 60% - 70% of the 2014 results. These results were in line with those of the nationwide athletic ability survey of children issued by the Japan Sports Agency (13, 18).

4.1. Statistical Analysis of the 2014 and 2022 Exams

The results of an unpaired *t*-test comparing the physical fitness exam results for third- and fourth-grade students in 2014 and students in the same grades in 2022 are shown in Table 3. As noted above, the *t*-test differentiated by grade, sex, and activity type.

4.2. Characteristics by Grade and Sex

Regarding third-grade boys and girls, a significant difference was observed in three (sit-ups, standing long jumps, and softball throws) and five out of eight tests (grip strength, sit-ups, the 20-m shuttle run, standing long jumps, and softball throws), respectively. For fourth-grade boys and girls, a significant difference was observed in five (grip strength, side steps, the 20-m shuttle run, standing long jumps, and softball throw) and four out of eight tests (grip strength, sit-ups, the 20-m shuttle run, and standing long jumps), respectively. Therefore, the athletic performance of third- and fourth-grade students after the spread of COVID-19 was judged to be inferior to that of the students in the same school year in 2014.

4.3. Characteristics by Activity Type

Regarding the activity type, no significant differences were observed in the trunk forward flexion (flexibility) and the 50-m run (instantaneous power) among any grade or sex. However, all other activities exhibited a $P < 0.05$ or $P < 0.01$ level of significant difference from either boys or girls in at least one grade. Specifically, for grip strength (muscle strength), sit-ups (muscle endurance), side steps (agility), 20-m shuttle runs (cardiopulmonary endurance), standing long jumps (instantaneous power), and softball throws (instantaneous movement), the performance of third- and fourth-grade students in 2022 was generally inferior to that in 2014.

4.4. Developments in 2023

Table 4 presents the physical fitness test records for A Elementary School in 2022 and 2023 by gender. In May 2023, COVID-19 restrictions were completely lifted from all forms of school education activities in Japan. Researchers therefore predicted that children's physical fitness exam results from 2023 would exhibit improvements compared to 2022 as learning activities —

Table 2. Physical Fitness Exam Results for Elementary School A, 2014 and 2022

Grade	Grip Strength (kg)	Sit-ups (No. Times)	Trunk Forward Flexion (cm)	Side Steps (No. Times)	20-M Shuttle Run (No. Times)	50-m Run (s) [a]	Standing Long Jumps (cm)	Softball Throws (m)
Boys								
Third								
2014 average	11.3	17.4	25.1	32.2	26.4	10.5	141	14.8
2022 average	10.9	15.1	26.7	31.9	25.8	10.2	135.7	12.2
Increase/decrease (%) [b]	96.7	86.6	106.3	99	97.8	-	96.2	82.5
Fourth								
2014 average	14.9	19.5	28.7	37.4	44.7	10	149	20.7
2022 average	13.3	17.5	28.6	33.6	27.6	10.1	137.8	15.1
Increase/decrease (%) [b]	88.9	89.8	99.4	90	61.6	-	92.4	72.9
Girls								
Third								
2014 average	10.9	18.3	29.8	28.4	24.8	10.8	127	8.7
2022 average	9.2	13.3	30.5	29.8	19.4	10.6	119.7	7.4
Increase/decrease (%) [b]	84.4	72.7	102.2	105	78.4	-	94.2	85.1
Fourth								
2014 average	13.4	18.7	33.9	33.4	32	10.3	140.1	10.6
2022 average	12.2	14.7	32.3	32.2	22.7	10.4	133.8	9.5
Increase/decrease (%) [b]	90.8	78.3	95.4	96.3	70.8	-	95.5	89.8

[a] In the 50-m runs, smaller numbers indicate better time results.

[b] The percentage of change in 2022 when 2014 is 100 is shown.

including physical education — had gradually resumed even before the restrictions were completely lifted. In fact, when comparing students of the same grade, the records for both boys and girls have generally improved. Furthermore, the 3rd-year students in 2022 are the 4th-year students in 2024 (Table 4).

Table 5 presents the results of an unpaired *t*-test comparing physical fitness data from June 2023 with those from 2014. The fourth graders in Table 5 correspond to the cohort evaluated as the third graders in Table 3. The comparison between 2023 and 2014 reveals no considerable differences in explosive physical abilities, such as standing long jump and softball throw, across most groups. However, in measures of muscle and overall endurance, 3rd- and 4th-year students in 2023 demonstrated notably inferior performance compared with their 2014 counterparts (this analysis compares records from the same school year and is not a longitudinal follow-up of the same group).

When the performance of the third-grade cohort from 2022 was compared with their performance as fourth graders in 2023, no significant improvement was observed in the P-value. In contrast, comparing the third and fourth graders in 2022 and 2023 (i.e., the same grade, not a follow-up survey), the P-value for 2023 appears to be improved compared to 2022; however, this is not a significant improvement.

In examining muscular endurance through sit-ups, the records of the third-year boys in 2022 did not considerably differ from those in 2014. However, once these boys progressed to fourth-year students in 2023, their athletic ability improved. Meanwhile, there was no improvement in the sit-up records for the girls.

Regarding the 20-m shuttle run (whole-body endurance), the records of the third-year boys in 2022 showed no significant difference compared with 2014. Nonetheless, once these boys became the fourth-year students in 2023, their performance significantly declined when compared with 2014. However, for girls, while their records as third-year students in 2022 were significantly inferior to those in 2014, no significant difference remained by 2023, indicating improvement in their performance.

When examining explosive events, there was no significant difference in the 50-m run between the

Table 3. Comparison of Third- and Fourth-Grade Physical Fitness Exams, 2014 and 2022 (Unpaired *t*-Test) [a]

Variables	Grip Strength	Sit-ups	Trunk Forward Flexion	Side Steps	20-m Shuttle Run	50-m Run	Standing Long Jumps	Softball Throws
Boys								
Third-grade	0.2476	0.0461 [b]	0.8754	0.4255	0.4252	0.9444	0.044 [b]	0.0294 [b]
Fourth-grade	0.0135 [b]	0.0809	0.4174	0.007 [c]	0.000004931 [c]	0.1899	0.008 [c]	0.0003 [c]
Girls								
Third-grade	0.00014 [c]	0.000032 [c]	0.686	0.6252	0.0112 [b]	0.9083	0.0264 [b]	0.0169 [b]
Fourth-grade	0.0025 [c]	0.000015 [c]	0.1529	0.1946	0.00028 [c]	0.3206	0.0181 [b]	0.0899

[a] P-value is not significant in the values which significance has not been mentioned.

[b] $P < 0.05$.

[c] $P < 0.01$.

Table 4. Physical Fitness Exam Results for Elementary School A, 2022 and 2023

Grade	Grip Strength (kg)	Sit-ups (Number of Times)	Trunk Forward Flexion (cm)	Side Steps (Number of Times)	20-m Shuttle Run (Number of Times)	50-m Run (s)	Standing Long Jumps (cm)	Softball Throws (m)
Boys								
Third								
2022 average	10.9	15.1	26.7	31.9	25.8	10.2	135.7	12.2
2023 average	11	15.3	31.4	35.4	26.7	10.1	140.2	13.9
Fourth								
2022 average	13.3	17.5	28.6	33.6	27.6	10.1	137.8	15.1
2023 average	12.2	17.6	29.8	37.6	31.6	10	146.3	15.7
Girls								
Third								
2022 average	9.2	13.3	30.5	29.8	19.4	10.6	119.7	7.4
2023 average	10.2	15.6	36.3	30.2	17.2	10.7	12.4.2	8.2
Fourth								
2022 average	12.2	14.7	32.3	32.2	22.7	10.4	133.8	9.5
2023 average	11	14.3	34.1	34.3	26.6	10.1	127.2	9.9

records for the same group of third-year students in 2022 and fourth-year students in 2023, compared with their 2014 performance. As for the standing long jump, while the fourth-year boys' performance showed no significant difference from their 2014 records, the difference for girls widened, indicating a greater decline in their performance.

5. Discussion

This study aimed to understand the impact of the COVID-19 pandemic restrictions on children's physical fitness so that the findings can be used to improve future physical education and contribute to children's mental and physical development. In Table 2, a simple comparison of the rate of increase or decrease of the mean values revealed that the decrease in results for sit-ups and the 20-m shuttle run was greater than those of grip strength (19), the latter of which represents the amount of muscle in the body. The *t*-test P-values demonstrated that the results for sit-ups and the 20-m shuttle run were extremely low, which was consistent with the results shown in Table 2. This decrease in muscle strength, which is related to endurance, appeared to be much greater among children than the decrease in other types of muscle fitness.

Compared to the Japan Sports Agency's survey results of fifth-grade elementary school students in 2020, the

Table 5. Comparison of Third- and Fourth-Grade Physical Fitness Exams, 2014 and 2023 (Unpaired *t*-Test) [a]

Variables	Grip Strength	Sit-ups	Trunk Forward Flexion	Side Step	20-m Shuttle Run	50-m Run	Standing Long Jump	Softball Throw
Boys								
Third-grade	0.6117	0.0982	0.0000008067 [b]	0.05965	0.0514	0.0390 [c]	0.0558	0.5086
Fourth-grade	0.00019979 [b]	0.1677	0.5619	0.9001	0.00004985 [b]	0.9296	0.5001	0.0016 [b]
Girls								
Third-grade	0.1506	0.0098 [b]	0.0000001222 [b]	0.2236	0.00001693 [b]	0.3258	0.3713	0.4008
Fourth-grade	0.00001164 [b]	0.0000003136 [b]	0.8119	0.3778	0.0596	0.1795	0.00011914 [b]	0.1457

[a] P-value is not significant in the values which significance has not been mentioned.

[b] $P < 0.01$.

[c] $P < 0.05$.

2021 survey recorded that the results for sit-ups, side steps, and 20-m shuttle runs were lower, and that trunk forward flexion had improved (13, 18). Similarly, this study compared the results from children's physical fitness exams in 2014 and 2022, assuming that children's body shapes (which were roughly the same) would not cause a significant difference. Therefore, this study cannot be compared to the survey results of the Japan Sports Agency (13), which demonstrated an increase in obesity.

Table 3 indicates a lag in performance in physical fitness activities outside of trunk forward flexion, which measures flexibility, and the 50-m run, which gauges instantaneous power. There was also a significant lag in performance in standing long jumps and softball throws (excluding fourth-grade girls), which, like the 50-m run, also gauge instantaneous power. The results of the standing long jump, which also measures strength and timing, demonstrated that the students' 2022 performance was inferior to that of 2014. In the softball throw, where similar coordination to the side step is required, the movement and agility results for 2022 were inferior to the 2014 results for fourth-grade boys.

Performance in the 20-m shuttle run and sit-ups, which measure cardiopulmonary and muscle endurance, respectively, are thought to have deteriorated because of changes in children's lifestyles due to the pandemic. Grip strength performance, which represents the amount of muscle in the body (19), was inferior in 2022 compared to 2014 (excluding third-grade boys). From the data in Tables 2 and 3, the high rate of decline in the 20-m shuttle run (whole-body endurance) and sit-ups (muscle endurance) was especially concerning. These activities place a large amount of strain on children through vigorous movements. In the future, it will be necessary to note whether the pandemic has had any influence on overall exercise behaviors as children grow.

Nagano et al. confirmed that compared to 2019, children's physical strength and athletic ability declined in 2020 because of the pandemic. Their study showed low results for the 50- and 20-m shuttle runs, which are affected by daily physical activity (17).

According to Scammon's developmental curve, motor skills such as dexterity and agility develop significantly during the third (ages 8 - 9 years) and fourth grade (ages 9 - 10 years) (20). Unfortunately, many children did not receive adequate physical exercise during this critical growth period due to the COVID-19 pandemic. A study targeting high school students found that motor functions deteriorated due to the self-restraint required by pandemic restrictions. Recovery may be challenging for some students, even when they resume training (21, 22). Studies on individuals who recovered from severe acute respiratory syndrome (SARS) suggest that contracting SARS can have long-term effects on athletic performance (11, 23). It is concerning that children infected with COVID-19 may experience similar effects. Additionally, this is the first societal experience of resuming exercise after a prolonged period of self-restraint. It is crucial for children to exercise appropriately according to their developmental stage, a concept known as "timeliness" (24). The impact of not receiving the right amount and quality of exercise at the right time during the pandemic needs to be closely monitored and investigated in the future.

In 2022, restrictions on school physical education due to COVID-19 were mostly lifted, allowing all grades to engage in practical physical education at school for 45 minutes, three times a week. A comparison of the P-values from Tables 3 and 5 indicated an improvement in explosive movements, such as the standing long jump

and softball throw, in 2023 compared to 2022 (when comparing records between the same grades rather than a follow-up comparison of the same groups). However, to determine whether there is steady improvement, it is necessary to closely monitor the development of physical fitness results in the same groups over time.

5.1. Conclusions

The results of the 2022 - 2023 physical fitness exams of third and fourth graders at Elementary School A in Japan were found to be significantly inferior in many aspects compared to the results of similar tests in 2014. The COVID-19 pandemic has negatively affected children's athletic performance by restricting their opportunities for exercise and physical education. School and community sports leaders must restart physical activity slowly and provide programs tailored to children's physical strength. Further research is needed on the best ways of conducting sports and physical education while considering both children's fitness needs and public health.

5.2. Study Limitations and Future Directions

This study compared physical fitness test data from a single school, Elementary School A, in Japan between 2014 and 2022; it was not a large-scale study. Moreover, it was a retrospective study, and a detailed investigation into the children's overall volume of physical activity was not conducted. Therefore, the exact nature of the pandemic's influence on children and how it changed their lifestyles and physical activity, resulting in a decline in physical fitness test results, is unknown. In the future, researchers must consider children's daily activities, school events, classes, and physical activities while paying attention to changes in their athletic performance and conducting further research, especially through prospective studies. Additionally, the activities examined in this study focused on the children's action-based physical strength, and other aspects of physical fitness were not considered. It is also necessary to eliminate confounding factors. In the future, it will be a challenge to teach children how to engage in balanced exercise while developing other factors for sound physical and mental development.

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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: S. I. conceived the idea of the study. S. I. developed the statistical analysis plan and conducted statistical analyses. S. I. and T. F. contributed to the interpretation of the results. S. I. drafted the original manuscript. H. I. and K. T. supervised the conduct of this study. All authors reviewed the manuscript draft and revised it critically on intellectual content. All authors approved the final version of the manuscript to be published.

Conflict of Interests Statement: The authors declare no conflict of interest.

Data Availability: The data that support the findings of this study are available from the corresponding author, S. I., upon reasonable request.

Ethical Approval: We also obtained ethical approval from the Kio University Graduate School of Health Sciences Research Ethics Review Committee (No. H28-06) and the Sakai City Principals' Association Elementary Education Study Group Physical Education Committee Ethics Review Committee (Mukaioka Branch) (No. sktm-1). The study was conducted in accordance with the Declaration of Helsinki.

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