Journal of Physical Activity Research, 2023, Vol. 8, No. 2, 73-77
Available online at http://pubs.sciepub.com/jpar/8/2/3
Published by Science and Education Publishing
DOI:10.12691/jpar-8-2-3

Effects of School Closure Due to COVID-19 on the Physical Fitness of Japanese Kindergarteners: A Longitudinal Study

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Received September 19, 2023; Revised October 20, 2023; Accepted October 26, 2023

Abstract The present study aimed to longitudinally clarify differences in physical fitness between Japanese kindergarteners who experienced school closure due to COVID-19 (COVID-19 pandemic group) and those who did not (control group). For the COVID-19 pandemic group, 51 children underwent physical fitness measurements at three years old in November 2019, four years old in November 2020, and five years old in November 2021. In the control group, 52 children underwent similar measurements at three years old in November 2017, four years old in November 2018, and five years old in November 2019. For physical fitness measurements, I performed an analysis of variance (ANOVA) of group × time for each gender. Regarding body support duration, the COVID-19 pandemic group performed significantly lower than the control group at four and five years old. The present study longitudinally revealed that muscle endurance among Japanese kindergarteners who experienced school closure due to COVID-19 was impaired.

Keywords: *early childhood, kindergarten, muscle endurance*

Cite This Article: Sho Aoyama, "Effects of School Closure Due to COVID-19 on the Physical Fitness of Japanese Kindergarteners: A Longitudinal Study." Journal of Physical Activity Research, vol. 8, no. 2 (2023): 73-77. doi: 10.12691/jpar-8-2-3.

1. Introduction

In recent years, a decline in children's physical fitness has become a problem in Japan [1]. Physical fitness in children has been shown to predict subsequent exercise habits [2]. In addition, there is a concern that declining physical fitness in children may lead to future health problems, such as obesity and other lifestyle-related diseases [2]. Therefore, in order to lead a healthy life, it is important to increase physical fitness from childhood.

Since January 2020, COVID-19 has spread all over the world, and people have been living under various restrictions [3]. With COVID-19 declared a pandemic, several countries announced nationwide school closures, affecting hundreds of millions of children [3, 4]. During the COVID-19 pandemic, school-going children around the world were ordered to stay home to mitigate the spread. The Japanese government declared a nationwide state of emergency from 16 April to 14 May 2020, and schools were closed during this period [5]. Many countries reported that children's physical activity decreased during school closures [6,7,8,9]. In Japan, similarly, the amount of physical activity among kindergarteners during school closures due to the COVID-19 pandemic decreased significantly [10]. A decline in physical activity during childhood leads to an increase in obesity and subsequent reduction in physical fitness [11,12,13]. Therefore, long-term school closures intended to prevent infectious diseases may adversely affect children's physical health, including increasing the number of obese children and lowering physical fitness levels [4]. Several reports show a decrease in children's physical fitness and increase in childhood obesity after COVID-19 [14,15,16,17]. However, since these reports only compare physical fitness measurement results before and after the COVID-19 pandemic, there is concern that the original physical fitness differences of each participant may be reflected.

It is thus necessary to clarify the effects of school closures due to COVID-19 on physical fitness by comparing the results measured at the same time before and after the pandemic with children who had shown the same physical fitness level before COVID-19. The present study is significant for recognizing the importance of improving the physical fitness levels of children. Additionally, it is necessary to consider the impact on children's physical fitness when considering school closures due to an outbreak of infectious diseases, such as COVID-19, in the future.

The purpose of the present study was to longitudinally clarify the difference in physical fitness between children who experienced school closures due to the COVID-19 pandemic in Japan (hereinafter referred to as the COVID-19 pandemic group) and those who did not (hereinafter referred to as the control group). It was assumed that the

physical fitness of children was hindered by the experience of school closures due to COVID-19.

2. Methods

2.1. Participants

Three classes from one of the four kindergartens in the town where the present study was conducted, were involved. The participants included 51 three-year-old Japanese children (26 boys, 25 girls; mean age (*M*) = 50.5 months, standard deviation (*SD*) = 3.1) enrolled in kindergarten A in November 2019 as the COVID-19 pandemic group. The control group included 52 three-year-old children (28 boys, 24 girls; *M* = 50.1 months, *SD* = 3.1) enrolled in kindergarten A in November 2017, which involved the same kindergarten as the COVID-19 pandemic group. The kindergarten attended by the participants of the present study was closed for about five weeks from 22 April 2020 to 31 May 2020 due to COVID-19. Therefore, children in the COVID-19 pandemic group experienced about five weeks of school closure. All participants spoke Japanese and had developed enough linguistic skills to understand the contents of the physical fitness measurements conducted in the present study. Most of the participants' parents were married and living together; most families lived in rural and non-urban locations, and the typical income level was middle class. The participants' mothers had an average level of education between high school and college. All participants followed the ministry's curriculum guidelines for kindergarten in Japan.

2.2. Ethical Considerations

The present study was conducted in compliance with the Declaration of Helsinki. I asked the parents of all children to participate in the present study by giving them a written statement, that stated that they would not be at any disadvantage if they did not agree to participate. All parents (100%) agreed to have their children participate and submitted a signed consent form. The present study protocol was approved by the Ethics Committee of Yamaguchi University (Approval number: 2022-051-01).

2.3. Procedure

The COVID-19 pandemic group underwent physical fitness measurements, including physique items (height and weight) in November 2019 (at three years old), November 2020 (at four years old), and November 2021 (at five years old). The control group underwent physical fitness measurements, including physique items (height and weight), in November 2017 (at three years old), November 2018 (at four years old), and November 2019 (at five years old). Physical fitness was measured in the kindergarten's field by an early childhood physical education instructor, who had extensive experience in physical fitness measurements for children. It took about 10 minutes to measure physical fitness per person.

2.4. Materials

I measured three physical fitness elements using the MKS early childhood physical fitness measurement [18,19], considering the burden on the participants. This measurement has been shown to be reliable and valid for assessing physical fitness during early childhood. I also measured the participants' height and weight.

2.4.1. Speed

A 25-m run (*s*) [18,19] was used to measure speed. The participants ran with maximum effort towards the goal line 30 m ahead, at the same time as the start signal was given, after taking a stance of 'preparation' with both feet spread forward and backward so as not to step on the starting line. The time from the start signal to passing the 25-m point was measured, and the time less than 1/100th of a second was discarded and recorded. For each participant, this test was measured once. The lower the number, the higher the speed capability.

2.4.2. Dexterity

Ball throw (*m*) [18.19] was used to measure dexterity. The participants threw a tennis ball as far as possible without running and without stepping on the 0-m line with the front foot. The distance from the 0-m line to the ball drop point was measured, and less than 50 cm was discarded and recorded. This test was measured twice for each participant. The better one was used as the representative value. The higher the number, the higher the dexterity ability.

2.4.3. Muscle Endurance

Body support duration (*s*) [18,19] was used to measure muscle endurance. The participants placed their hands on the pedestals placed at both ends, 30 cm apart, took a posture with both elbows extended, lifted both feet off the floor at the same time as the 'start' signal, and maintained this posture for as long as possible. The time until the participant could no longer support their weight with both arms was measured in seconds, and 180 seconds was recorded as the maximum, considering the burden on the participants. This test was performed only once. The higher the number, the higher the muscle endurance ability.

2.5. Statistical analyses

All statistical tests were two-tailed, and a p-value of .05 was employed. Data were analysed with IBM SPSS Statistics for Windows, Version 27 (IBM Corporation, Armonk, New York, USA). For each measurement item, an analysis of variance (ANOVA) was performed for each of the boys and girls by group (COVID-19 pandemic group and control group) × measurement time (at three years old, four years old, and five years old). The significance level was set at less than 5%. When interactions were significant, simple main effects were tested. The Kaup index was calculated by dividing the weight (kg) by the square of the height (m).

Table 1. Analysis of variance (ANOVA) results for each measurement item

Measures	Gender	COVID-19 pandemic group						Control group						Main effect (time)		Main effect (group)		ANOVA (group × time)	
		At 3 years old		At 4 years old		At 5 years old		At 3 years old		At 4 years old		At 5 years old							
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	η^2	*F*	η^2	*F*	η^2
Height(cm)	boys	100.46	4.37	107.08	4.42	113.23	4.55	100.13	3.16	107.46	3.34	114.15	3.39	2784.17***	1.00	0.04	0.00	1.36	0.07
Weight (kg)		15.33	1.42	17.63	2.08	19.73	2.79	15.64	2.21	18.56	3.49	20.98	4.24	118.08***	0.86	0.47	0.02	1.15	0.06
Kaup index		15.18	0.84	15.34	1.02	15.34	1.32	15.56	1.58	16.00	2.24	16.02	2.43	1.71	0.08	0.04	0.03	0.40	0.02
25m run (s)		10.49	1.62	8.32	0.45	8.40	0.91	9.73	1.01	8.49	0.56	7.72	0.40	59.58***	0.76	1.70	0.08	3.34	0.15
Ball throw (m)		3.50	0.94	5.60	1.65	7.05	2.48	3.82	1.08	5.18	1.60	6.91	2.57	24.63***	0.56	0.02	0.00	0.31	0.02
Body support duration (s)		23.40	8.97	27.90	11.75	33.50	22.74	23.91	14.12	65.00	39.12	72.91	54.05	11.46***	0.38	5.39*	0.22	5.69*	0.23
Height(cm)	girls	97.88	4.46	104.95	4.71	111.09	4.99	99.57	3.97	107.23	4.21	113.58	4.63	1421.91***	0.99	1.18	0.06	1.31	0.06
Weight (kg)		14.75	1.21	17.35	1.47	19.02	1.98	16.20	1.92	18.99	2.78	21.69	3.35	171.23***	0.90	2.49	0.18	3.11	0.13
Kaup index		15.40	0.77	15.75	0.93	15.41	1.26	16.29	1.05	16.45	1.47	16.73	1.53	1.63	0.08	1.38	0.17	2.18	0.10
25m run (s)		10.86	1.28	8.54	0.70	8.59	0.71	9.91	1.26	8.35	0.54	7.68	0.47	58.40***	0.74	1.26	0.23	1.84	0.08
Ball throw (m)		2.77	1.44	3.77	1.40	4.36	2.52	3.45	0.85	5.50	1.26	6.41	1.32	19.49***	0.49	1.46	0.30	1.85	0.08
Body support duration (s)		20.55	7.42	27.64	8.46	43.91	24.78	26.27	10.74	56.09	18.47	79.45	36.11	31.38***	0.61	12.09**	0.38	5.20*	0.21

*$p < .05$, **$p < .01$, ***$p < .001$

3. Results

The ANOVA (shown in Table 1) revealed no significant interaction for height, weight, Kaup index, 25-m sprint, and ball throwing for both boys and girls. On the other hand, the interaction of body support duration for boys (F (2,38) = 5.69, $p < .05$, $\eta^2 = 0.23$) and girls (F (2,40) = 5.20, $p < .05$, $\eta^2 = 0.21$) was significant.

As the interaction of body support duration for boys and girls was significant, a simple main effect test was performed for each. Consequently, regarding body support duration for boys, the COVID-19 pandemic group (M = 27.9, SD = 11.8) had significantly lower performance than the control group (M = 65.0, SD = 39.1) at four years old ($p < .05$). The COVID-19 pandemic group (M = 33.5, SD = 22.7) performed significantly lower than the control group (M = 72.9, SD = 54.1) at five years old ($p < .05$). In the control group, the result at four years old (M = 65.0, SD = 39.1) was significantly higher than that at three years old (M = 23.9, SD = 14.1) ($p < .001$). The result at five years old (M = 72.9, SD = 54.1) was significantly higher than that at three years old (M = 23.9, SD = 14.1) ($p < .001$). Regarding body support duration for girls, the COVID-19 pandemic group (M = 27.6, SD = 8.5) had significantly lower performance than the control group (M = 56.1, SD = 18.5) at four years old ($p < .001$). The COVID-19 pandemic group (M = 43.9, SD = 24.8) performed significantly lower than the control group (M = 79.5, SD = 36.1) at five years old ($p < .05$). In the control group, the result at four years old (M = 56.1, SD = 18.5) was significantly higher than that at three years old (M = 26.3, SD = 10.7) ($p < .001$); the result at five years old (M = 79.5, SD = 36.1) was significantly higher than that at four years old (M = 56.1, SD = 18.5) ($p < .05$); and the result at five years old (M = 79.5, SD = 36.1) was higher than that at three years old (M = 26.3, SD = 10.7) ($p < .001$). In the COVID-19 pandemic group, the result at five years old (M = 43.9, SD = 24.8) was significantly higher than that at three years old (M = 20.5, SD = 7.4) ($p < .05$).

4. Discussion

A significant reduction in physical activity after the COVID-19 pandemic was reported in children aged 6 to 17 years in China compared to before the pandemic [9]. On the other hand, for children aged 4 to 17 in Germany, although the amount of physical activity at schools and sports clubs that were not implemented during the lockdown under the COVID-19 pandemic decreased, the amount of physical activity such as outdoor play in the park and walking increased [20]. It was impossible to go outside to exercise during the lockdown in China. Therefore, regarding the difference in the impact of activity restrictions due to the COVID-19 pandemic on the amount of physical activity of people between countries, it has been suggested that there is a difference in the degree of movement restriction measures between countries [20]. In Japan, schools were temporarily closed nationwide, but strict behavioural restrictions such as curfews were not enforced [21]. Indeed, during the COVID-19 pandemic in Japan, it has been reported that kindergarteners engaged in some form of physical activity with their parents at or near their homes [15,16]. During the state of emergency declaration from 16 April 2022 to 14 May 2022, school closures were implemented to prevent the spread of COVID-19 [5]. Five-week-long school closures from 22 April 2020 to 31 May 2020 were also implemented at the participants' kindergarten. The school was opened as usual after the closure measures were lifted, regardless of the spread of COVID-19. Considering the burden on parents and children, the school closure period was limited to five weeks. Even during this period, opportunities were available for physical activity that could be done at and around the home. This situation may explain why the development of the Kaup index, speed, and dexterity was not affected.

The results of the present study revealed that school closure due to COVID-19 inhibited the development of muscular endurance in boys and girls. At the kindergarten that the participants attended, there were opportunities for children to play with playground equipment that required muscular endurance, such as pull-up bars and monkey bars. Due to school closure, the opportunity to exercise using playground equipment, which is difficult at home, was lost for about five weeks, which is thought to have caused the decline in muscle endurance. COVID-19 could also be transmitted through physical contact with objects previously touched by infected individuals [22]. Therefore, it is assumed that long-term restrictions on the use of playground equipment that required muscular endurance, such as pull-up bars and monkey bars in kindergarten playgrounds and parks, led to a decline in muscular endurance.

Few studies examined the effects of school closures during the COVID-19 pandemic on childhood obesity and physical fitness in children who had similar physical fitness levels before the COVID-19 pandemic. Regarding this point, in the present study, I compared the results of physical fitness measured at the same time before and after the COVID-19 pandemic, targeting kindergarteners who showed the same physical fitness levels before the COVID-19 pandemic. Consequently, it was shown that school closure due to COVID-19 did not affect the development of height, weight, Kaup coefficient, speed, and dexterity, but inhibited the development of muscle endurance compared to the control group. The strength of the present study is that I compared the results of physical fitness measured in the same kindergarten during the same period before and after the COVID-19 pandemic, in children who showed similar physical fitness before COVID-19, to focus on comparisons based on experience with school closure. The results obtained in the present study have led to important findings on the physical fitness of children for parents and teachers, who are involved with children daily, when kindergartens implement school closure measures in the future. In the future, there is enough concern that unknown infectious diseases, such as COVID-19, could spread globally, causing school closures to prevent them spreading. Considering the present study's results, it is necessary to perform intentional exercises for improving muscle endurance at home, according to the actual situation of kindergarteners when school closure measures are implemented in the future.

The results of the present study were obtained from children who attended only one kindergarten and lived in rural areas, not urban ones. To focus on comparisons according to school closure, I compared the results measured at the same kindergarten at the same time before and after the COVID-19 pandemic, but the small sample size could limit the present study's generalizability. Therefore, future studies should examine the impact of school closure due to COVID-19 on the physical fitness of children living in urban areas. Another limitation of the present study was that I was unable to measure the amount of physical activity and other fitness factors except for participants' speed, dexterity, and muscle endurance.

5. Conclusion

The results of the present study showed that school closure due to COVID-19 did not influence the development of height, weight, Kaup coefficient, speed, and dexterity, but inhibited the development of muscle endurance in kindergarten children, compared to the control group. The results obtained in this study should be used to intentionally implement exercises aimed at improving muscle endurance in kindergarteners, when schools are closed long-term (due to a pandemic or an infectious disease) in the future.

ACKNOWLEDGEMENTS

This work is supported by the research institute for time studies in Yamaguchi University.

Statement of Competing Interests

The author has no competing interests.

References

[1] Nippon communications foundation. Survey finds decline in physical fitness among Japanese children. Retrieved from https://www.nippon.com/en/japan-data/h00632/survey-finds-decline-in-physical-fitness-among-japanese-children.html. 2020 [Accessed 26 September 2023].

[2] Barnett, L.M., van Beurden, E., Morgan, P.J., Brooks, L.O., & Beard, J.R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescence Health*, 44(3), 252–259.

[3] World Health Organization. Director-General's opening remarks at the media briefing on COVID-. Retrieved from https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 [Accessed 26 September 2023].

[4] Wang, G., Zhang, Y., Zhao, J., Zhang, J., & Jiang, F. (2020). Mitigate the effects of home confinement on children during the COVID-19 outbreak. *Lancet*, 395(10228), 945–947.

[5] Isumi, A., Doi, S., Yamaoka, Y., Takahashi, K., & Fujiwara, T. (2023). Do suicide rates in children and adolescents change during school closure in Japan? The acute effect of the first wave of COVID-19 pandemic on child and adolescent mental health. *Child Abuse & Neglect*, 110(2), 104680.

[6] Dunton, G.F., Do, B., & Wang, S.D. (2023). Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the US. *BMC Public Health*, 20(1351), 1–13.

[7] Medrano, M., Cadenas-Sanchez, C.C., Oses, M., Arenaza, L., Amasene, M., & Labayen, I. (2021). Changes in lifestyle behaviours during the COVID-19 confinement in Spanish children: A longitudinal analysis from the MUGI project. *Pediatric Obesity*, 16(4), e12731.

[8] Moore, S.A., Faulkner, G., Rhodes, R.E., Brussoni, M., Chulak-Bozzer, T., & Tremblay, M.S. (2020). Impact of the COVID-19 virus outbreak on movement and play behaviours of Canadian children and youth: a national survey. *The international Journal of Behavioral Nutririon and Physical Activity*, 17(1), 85.

[9] Xiang, M., Zhang, Z., & Kuwahara, K. (2020). Impact of COVID-19 pandemic on children and adolescents' lifestyle behavior larger than expected. *Progress in Cardiovascular diseases*, 63(4), 531–532.

[10] Kim, H., Jiameng, M., Sunkyoung, L., & Ying, G. (2021). Change in Japanese children's 24-hour movement guidelines and mental health during the COVID-19 pandemic. *Scientific Reports*, 11(22972), 1–9.

[11] Abbott, R.A., & Davies, P.S. (2004). Habitual physical activity and physical activity intensity: their relation to body composition in 5.0–10.5-y-old children. *European Journal of Clinical Nutrition*, 58(2), 285–291.

[12] Brazendale, K., Beets, M.W., Weaver, R.G., Pate, R.R., McGrievy, G.M.T., & Kaczynski, A.T. (2017). Understanding differences between summer vs. school obesogenic behaviors of children: the structured days hypothesis. *The International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 1–14.

[13] Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessels, S., & Greenberg, N. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *Lancet*, 395(10227), 912–920.

[14] Basterfield, L., Burn, N.L., Galna, B., Batten, H., Goffe, L., & Karoblyte, G. (2022). Changes in children's physical fitness, BMI and health-related quality of life after the first 2020 COVID-19 lockdown in England: A longitudinal study. *Journal of Sports Sciences*, 40(10), 1088–1096.

[15] Ito, T., Sugiura, H., Ito, Y., Noritake, K., & Ochi, N. (2021). Effect of the COVID-19 emergency on physical function among school-aged children. *International of Journal of Environmental Research and Public Health*, 18(18), 1–8.

[16] Pombo, A., Luz, C., de Sá, C., Rodrigues, L.P., & Cordovil, R. (2021). Effects of the COVID-19 lockdown on Portuguese children's motor competence. *Children*, 8(3), 1–10.

[17] Abe, T., Kitayuguchi, J., Fukushima, N., Kamada, M., Okada, S., & Ueta, K. (2022). Fundamental movement skills in preschoolers before and during the COVID-19 pandemic in Japan: a serial cross-sectional study. *Environmental Health and Preventive Medicine*, 27(26), 26.

[18] Goshi, F., Demura, S., Kasuga, K., Sato, S., & Minami, M. (1999). Selection of effective tests of motor ability in preschool children based on pass-or-fail criteria: examination of reliability, objectivity, and rate of passing. *Perceptual and Motor Skills*, 88(1), 169–181.

[19] Ministry of Education. Culture, sports, science and technology. Japan. The early childhood exercise guidelines (Youjiki Undou Shishin), 2021. Retrieved from https://www.mext.go.jp/a_menu/sports/undousisin/1319772.htm [Accessed 26 September 2023].

[20] Schmidt, S.C.E., Anedda, B., Burchartz, A., Eichsteller, A., Kolb, S., & Nigg, C. (2020). Physical activity and screen time of children and adolescents before and during the COVID-19 lockdown in Germany: A natural experiment. *Scientific Reports*, 10(1), 21780.

[21] Hyunshik, K., Jiameng, M., & Sunkyoung, L. (2021). Change in Japanese children's 24-hour movement guidelines and mental health during the COVID-19 pandemic. Scientific Reports, 11, 22972.

[22] Centers for Disease Control and Prevention. COVID-19. Considerations for youth sports administrators, 2020 https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/youth-sports.html [Accessed 26 September 2023].

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