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Effects of Exercise-play on Japanese Preschool Children's Motor Ability and Physical Fitness

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Abstract This study's twofold aim was (1) to determine the effects of a program of exercise-play (PEP) on the motor ability and physical fitness of nursery-type children in a certified Center for Early Childhood Education and Care (ECEC) in Japan and (2) to evaluate changes in their motor ability and physical fitness after the PEP intervention. Once their parents provided informed written consent, 54 ECEC preschoolers (19 nursery-type and 35 kindergarten-type children.) were enrolled in the study. We introduced PEP for the 19 nursery-type children (PEP-introduced group). The 35 kindergarten-type children (PEP-unintroduced group) were cared for as usual, without PEP. In both groups, we measured continuous jumps with both legs, the standing long jump, one-leg beam balance, and toe muscle strength three times—before introducing PEP, after the intervention, and 7 months post-intervention. Findings revealed that before the PEP intervention, nursery-type children's motor ability and physical fitness were inferior to that of the kindergarten-type children. Continuous jumps with both legs and the one-leg beam balance improved in the PEP-introduced group after the PEP intervention, but not in the PEP-unintroduced group. In addition, the standing long jump and toe muscle strength increased in both groups, but the effect (degree of increase) was greater in the PEP-introduced group than in the PEP-unintroduced group. Regarding relative superiority between groups in motor ability and physical fitness, the PEP-introduced group was inferior or equivalent before the PEP intervention. As a result of PEP intervention, the PEP-introduced group's inferior items became equivalent, and the equivalent item became superior. However, by 7 months after PEP ended, the groups' superiority returned to the level prior to the PEP intervention. These results indicate that although PEP effectively improved the nursery-type children's motor ability and physical fitness, 7 months after PEP cessation, these effects had disappeared.

Keywords: *Certified Center for Early Childhood Education and Care, Preschoolers, Motor ability, Physical fitness, Program of exercise-play*

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1. Introduction

Following World War II, Japanese law stipulated nursery school for childcare and kindergarten for early childhood education. Currently, nursery schools must provide 11 hours of daily childcare, and kindergartens must provide 4 hours of daily instruction [1]. In addition, as of 2006, local governments have facilities designated "Certified Centers for Early Childhood Education and Care" (ECEC) that serve as kindergartens and nursery schools. In Japanese ECEC, some preschoolers (nursery-type) receive about 7 hours of childcare in addition to 4 hours of education and others (kindergarten-type) receive about 4 hours of education.

Mori, S. et al. [2] have reported that nursery children have less developed motor abilities than kindergarteners because nursery schools frequently have inefficient institutional settings, for instance, smaller playrooms and playgrounds than kindergartens. In contrast, Toda, Y. et al. [3] found no difference in motor ability between nursery-type and kindergarten-type children in an ECEC. They stated that in the ECEC, nursery-type children are active longer than kindergarten-type children and that kindergarten-type children might engage in sports-related lessons after returning home. They speculated that overall the two groups differed little in daily activity.

At this study's ECEC site, we regularly measured children's motor ability and physical strength. Similar to Mori, S. et al. [2], our results showed that nursery-type children tended to have lower motor abilities and physical strength than kindergarten-type children. Unlike Mori, S. et al. who ascribed the difference to the physical environment, we believe that the difference is due to nursery children's lack of spontaneous exercise-play in the institution. If so, providing nursery-children a suitable exercise regimen could be vital to enhancing their motor abilities.

Previous studies on physical activity's effects on non-Japanese preschool children [4,5,6] reported significant improvements in motor development following activity-based interventions. For Japanese preschool children, Miyaguchi, K. et al. [7] reported ladder exercise as particularly effective for developing nursery-care children's various reaction movements. Moreover, Yoshimi, E. et al. [8] reported that a rhythmic play-exercise program improved kindergarteners' coordination-related motor skills. However, no studies have examined effects of physical exercise interventions on motor ability and physical fitness in children of Japanese ECEC. Furthermore, no studies have examined preschool children's changes in motor ability and physical fitness after an exercise program intervention.

Therefore, in a Japanese ECEC, this study investigated effects of a program of exercise-play (PEP) on nursery-type children's motor ability and physical fitness; after the PEP intervention, the study evaluated changes in the children's motor ability and physical fitness.

2. Materials and Methods

2.1. Sample Size and Sampling Procedures

Based on the work of Bradley, D. R. [9], sample size was calculated using the package "pwr" (Basic Functions for Power Analysis) of the statistical analysis software "R" with a script [10]. At that time, the significance level was 0.05, and the power 0.8. In addition, effect size was set to 0.35—quite large [11]—because, from previous studies [2], a clear intergroup difference was expected. Additionally, autocorrelation was set to 0.35 based on our previous measurements' results. Because the calculation indicated a sample size of 19 for each group, we tried to have no fewer than 19 participants per group.

The study's ECEC, in Yokohama city, Kanagawa prefecture, had three classes, with each class having a mixture of children receiving nursery-type care and kindergarten-type care. In particular, the study targeted 4-year-old children (n = 80) receiving care at this ECEC. Of these, 23 received nursery-type care, and 57 received kindergarten-type care. After subtracting from these the children whose parents did not consent and the children who were unable to receive any of the first, second and third measurements, the study finally evaluated 19 nursery-type children and 35 kindergarten-type children. The 19 nursery-type children (9 boys, 10 girls; PEP-introduced group) participated in the PEP that we presented during care. The 35 kindergarten-type children (18 boys, 17 girls) received the usual care (PEP-unintroduced group). Figure 1 illustrates the sampling procedure.

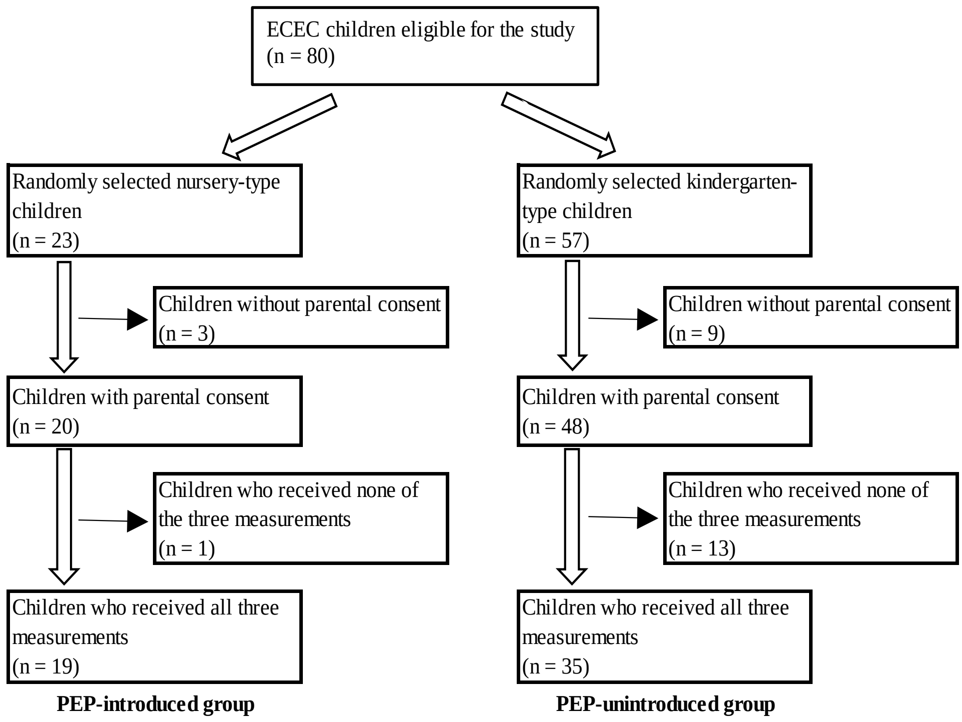

Figure 1. Sampling Procedure for This Study's ECEC PEP Intervention

2.2. Measurement Methods

We tested the three motor skills and toe muscle strength before introducing PEP (first measurement), a day after the PEP intervention period (second measurement), and 7 months after PEP ended (third measurement).

In Japan, the MKS test battery, named for its developers Matsuda, Kondo, and Sugihara [12,13], is commonly employed to assess preschool children's motor ability. From the MKS test battery, we selected two measurement items using the lower limbs—continuous jumps with both legs and the standing long jump—because it is believed that movement using the lower limbs plays a significant role in the children's physical growth and development stage [13]. A 25-meter run is part of the MKS test battery, but because it could not be assessed at this ECEC, it was not implemented. Because the MKS test battery does not include an item for evaluating balance, the one-leg beam balance was added to the two items above. Furthermore, toe muscle strength, which has significant relation to children's motor ability [14,15], was also added. Thus, we adopted these four measurement items: continuous jumps with both legs that reflect the lower limbs' agility, the standing long jump that demonstrates the lower limbs' power, the one-leg beam balance that demonstrates the ability to balance with the lower limbs, and toe muscle strength that indicates force to grab the ground or floor with the toes. Of these four items, continuous jumps with both legs, the standing long jump, and the one-leg beam balance were measured according to Japan's standard methods [12,13,16,17,18].

Standing long jump:

Figure 2 illustrates the standing long jump in which children jump from a standing position with both feet as far as possible. The tester measures the shortest distance between the starting and landing points. The longer of the measurements was recorded after the measurement was conducted twice.

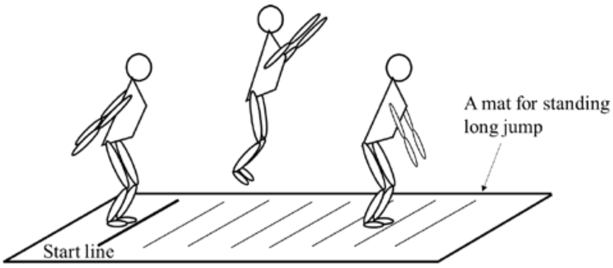

Figure 2. Standing Long Jump Test Illustrated

Continuous jumps with both legs:

Figure 3 illustrates continuous jumps with both legs in which children precisely and rapidly leap with both feet over ten wooden blocks spaced 50 cm apart. The tester records each jump's duration in fractions of a second. The greater of the results was recorded after the measurement was conducted twice.

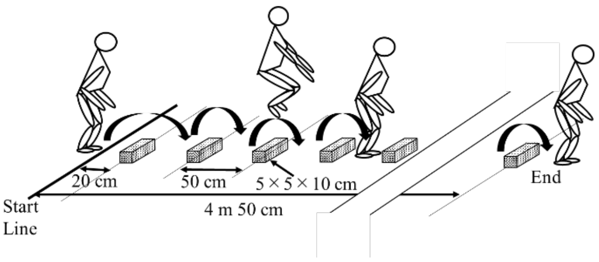

Figure 3. Continuous Jumps with Both Legs Test Illustrated

One-leg beam balance:

Figure 4 illustrates the one-leg beam balance. The child places both hands at the waist, stands on one foot on a board of the specified size, and maintains the position as long as possible. The tester counts the seconds that pass between the child's other foot leaving the ground and when it again touches the ground. The left and right legs were each measured twice. For each left and right, the longer of the measurements was recorded, and the left and right values' averages were assessed.

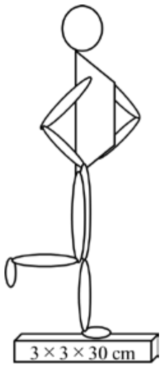

Figure 4. One-leg Beam Balance Test Illustrated

Toe muscle strength:

This measurement was completed using the methods of Fukumoto, T. et al. [19] and Soma, M. et al. [20]. A toe muscle strength measuring instrument (TKK3361 made by Takei Scientific Instruments Co., Ltd.) was used.

Figure 5 illustrates toe muscle strength measurement. The instrument was placed under the seated child's feet, and the child sat upright with the back not touching the chair's backrest, with the knees bent to approximately 90 degrees, and with the hands on the knees. The child hung one foot's toe on the instrument's grasping bar; to keep the foot's heel on the device; the tester gripped the child's ankle. The child flexed the toes with maximum effort. The left and right toes were each measured twice, and the larger measurement value was recorded for each of the left and right toes. The average of the left and right values was also calculated.

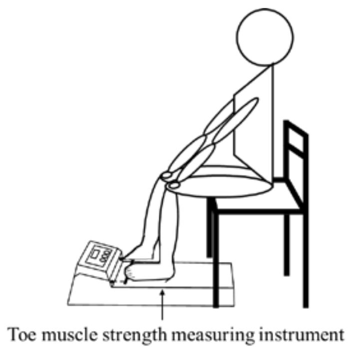

Figure 5. Toe Muscle Strength Test Illustrated

2.3. PEP

The PEP was developed in accordance with the *Youji-ki Undou Shishin* (exercise guidelines for early childhood) [12] to accommodate the target children's present age, growth, and development, incorporate a variety of movements, and induce and maintain their interest. Table 1 displays the PEP goals and its specific contents. An external instructor acquainted with the CECE's educational and childcare regulations delivered PEP instruction, which occurred over 3 months, 2 or 3 days a week, for approximately 1 hour. The external instructor focused on motivating the children to exercise.

Table 1. The PEP's Goals and Specific Contents

Title	Goal	Content of exercise play
Paper ring catch	Familiarity with throwing motion. Promotion of development of cooperation, dexterity, physical cognitive ability, and spatial cognitive ability	Prepare a paper ring about 20 cm in diameter. One child throws the ring up, and another child either catches the falling ring or puts his/her hand inside it.
Elastic cord jump	Familiarity with jumping motion. Promotion of development of whole-body endurance, cooperation, dexterity, physical cognitive ability, and spatial cognitive ability	Prepare two elastic cords of 2–3 m. Install at a height of 20-30 cm and a width of 20 cm. While jumping repeatedly to a song, move from one elastic cord to the other, align both legs between the elastic cords, open both legs, and straddle both elastic cords and place the left and right foot on the elastic cords. This series of movements is repeated several times.
Cloth ball catch	Familiarity with throwing movements. Promotion of development of cooperation, dexterity, physical cognitive ability, and spatial cognitive ability	A light, soft, and easy-to-grasp ball with a shape and matearial of 14 cm in diameter can be thrown upward to catch it as it falls, or it can be moved freely around the body.
Rock-paper Gombe-san [21]	Familiarity with jumping motion. Promotion of development of cooperation, dexterity, equilibrium, physical cognitive ability, and spatial cognitive ability	Place one of each of the three rock-paper-scissors cards next to your feet at 30 cm intervals. Stand in front of a card so as not to step on it, sing a song, and jump on the spot in front of the card. Once you get used to it, place the cards vertically and diagonally.
Jump a circular hose	Familiarity with jumping and running movements. Promotion of development of dexterity, agility, equilibrium, physical cognitive ability, and spatial cognitive ability	Place one circular hose with a diameter of 20 cm at your feet and jump in and out with both feet and then one foot. When you get used to it, line up 5 to 8 pieces in front of you and jump in with one or both feet.
Straw catch	Promotion of muscle strength (legs, toes), balance, dexterity, and physical cognitive ability	Place one straw on the floor, hold it with your toes while standing on the other foot, and lift it up to your hand to pick it up. Once accustomed to this, compete with others to see who can pick up the most straws quickly.
Plastic bag catch [21]	Promotion of agility, responsiveness, physical cognitive ability, and spatial cognitive ability	Fill a plastic bag with a handle (thank you bag, width 15 cm) with air, throw it upward, and then grab the falling bag. At first, one person does it, and after getting used to it, two people do it.
Newspaper runner	Familiarity with running movements. Promotion of development of instantaneous power, muscle strength (legs), agility, and spatial cognitive ability	Spread the newspaper, raise your hands, and run so that the newspaper does not fall. Also, cut the newspaper into 10 cm wide pieces, hold it in your hands, raise your hands, and run so that it is the newspaper stays level with the ground.
Hornworm walking	Promotion of development of muscle strength (legs and toes)	Draw two lines sideways with a gap of 30 cm and use the front line as the start line. With a signal from the front of the start line, only the movement of the toes advances until the fingertips reach the back line.

2.4. Methods of Data Analysis

All measurement data are shown as mean ± standard deviation (± SD).

Averages for each item for boys and girls were investigated separately at each of the three measurement times. The PEP-introduced group and the PEP-unintroduced group were examined using Welch's t-test, and the obtained p values were adjusted by Bonferroni's method.

Based the analytical results of differences between boys and girls, subjects for subsequent analysis were the total of boys and girls. Two-factor analysis of variance (ANOVA) was performed with the PEP-introduced group and the PEP-unintroduced group as one factor (with no correspondence) and the "measurement" of the first, second and third measurements as the other factor (with correspondence), using Excel statistics version 2.15 (Social Information Service Co., Ltd.). Homoscedasticity was confirmed by Levene's method, and sphericity by Mauchly's method. When homoscedasticity is not satisfied, the group factor's significance might be a type 1 error (i.e., the one with no difference is judged to differ). Thus, we adjusted the Welch's t-test results by Bonferroni's method to confirm the significance of the between-group difference. If sphericity was not satisfied, Huynh-Feldt-Lecoutre's epsilon was used for correction. If the interaction was significant because of two-factor ANOVA, a test of simple main effect was performed, using Tukey's method for a multiple comparison test.

Welch's t-test was also used to examine the degree of change between groups for items that indicated significant changes from the first to the second measurement in both the PEP-introduced group and the PEP-unintroduced group. All significance levels were < 5% ($p < 0.05$).

2.5. Ethical Clearances

The Human Research Ethics Review Committee of Nippon Sport Science University (015-H42) and Kanto Gakuin University (Person 2014-1-1) both approved the study. We fully explained the study content and personal-information protection both in writing and verbally to the participants' parents, and concerned others, to obtain their written informed consent.

3. Results

As previously mentioned, we analyzed results for any gender difference in each item's three measurements for the PEP-introduced group and the PEP-unintroduced group, but no gender differences were statistically significant. Thus, subsequent analysis was based on the sum of boys and girls.

3.1. Body Height and Weight

Table 2 displays outcomes of two-factor ANOVA for body height and weight. The group factor and the interaction were not significant in any items, but the measurement factor was significant in all of them ($p < 0.01$).

Table 2. Results of Two-factor ANOVA for Children's Body Height and Weight

	Factor	F
Body height (cm)	Group	1.036
	Measurement	158.910 **
	Interaction	1.328
Body weight (kg)	Group	1.093
	Measurement	166.505 **
	Interaction	0.322

**: p < 0.01

The body height of the PEP-introduced group first measured 104.0 ± 4.96 (±SD) cm, second 105.9 ± 4.81 cm, and third 110.2 ± 5.00 cm. In the PEP-unintroduced group, the first measurement was 104.4 ± 3.57 cm, the second 107.5 ± 3.74 cm, and the third 111.6 ± 4.10 cm. The body weight of the PEP-introduced group first measured 16.0 ± 2.48 kg, second 16.6 ± 2.56 kg, and third 18.3 ± 2.36 kg. In the PEP-unintroduced group, the first measurement was 16.7 ± 1.68 kg, the second was 17.3 ± 1.82 kg, and the third was 18.8 ± 1.98 kg. In both groups, changes of body height and weight from the first measurement to the second measurement, the first to the third, and the second to the third were all statistically significant ($p < 0.01$). These findings are consistent with young children's normal growth and development.

3.2. Three Motor Abilities and Toe Muscle Strength

Table 3 shows the outcomes of two-factor ANOVA for three motor abilities and toe muscle strength. In each measurement item, the interaction was significant ($p < 0.05$ or $p < 0.01$), so simple main effect tests were also performed.

Table 3. Results of Two-factor ANOVA in Three Motor Abilities and Toe Muscle Strength

	Factor	F
Standing long jump (cm)	Group	4.672 **
	Measurement	51.371 **
	Interaction	6.634 **
Continuous jumps with both legs (s)	Group	1.170
	Measurement	39.546 **
	Interaction	10.061 **
One-leg beam balance (s)	Group	1.514
	Measurement	5.366 **
	Interaction	6.816 **
Toe muscle strength (kg)	Group	4.053 *
	Measurement	26.102 **
	Interaction	3.661 *

*: p < 0.05; **: p < 0.01

Figure 6 displays standing long jump changes from the first to the third measurement in both groups. The first measurement in the PEP-introduced group was 75.5 ± 12.79 cm, the second 93.4 ± 7.28 cm, and the third 95.0 ± 12.47 cm. In the PEP-unintroduced group, the first measurement was 88.1 ± 15.95 cm, the second 93.7 ± 13.02 cm, and the third 102.1 ± 11.65 cm.

As a result of the simple main effect test, the group factor was significant ($p < 0.01$) in the first measurement, and the measurement factor was significant ($p < 0.01$) in both groups. A multiple comparison test on the measurement factor showed significant differences between the first and second measurements in both groups ($p < 0.01$). Additionally, both groups showed substantial changes ($p < 0.01$) from the first to the third measurement, while the PEP-unintroduced group showed significant changes ($p < 0.01$) from the second to the third measurement.

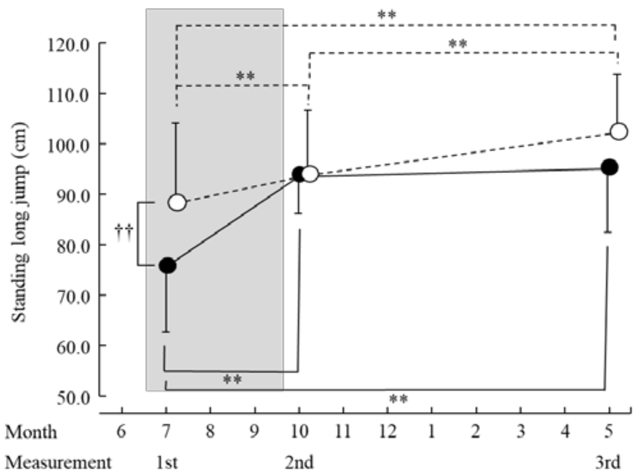

Figure 6. Changes in Standing Long Jump from the First to the Third Measurement in the PEP-introduced Group (Black Circles) and the PEP-unintroduced Group (White Circles)
Values are Mean ± SD.
: PEP Introduction Period
**: p < 0.01; ††: p < 0.01

Figure 7 illustrates how both groups' continuous jumps with both legs changed from the first to the third measurement. In the PEP-introduced group, the first measurement was 6.78 ± 1.214 s, the second 5.05 ± 0.498 s, and the third 5.08 ± 0.846 s. In the PEP-unintroduced group, the first measurement was 6.47 ± 1.421 s, the second 6.24 ± 1.433 s, and the third 4.90 ± 0.685 s.

The simple main effect test showed that the group factor was significant ($p < 0.01$) in the second measurement, in which a significant difference ($p < 0.01$) occurred in the variance between the two groups. Thus, the result of Welch's t-test was corrected by Bonferroni's method, revealing a significant difference ($p < 0.01$) between the two groups in the second measurement.

Similarly, the simple main effect test showed the measurement factor to be significant ($p < 0.01$) in each group. In multiple comparison tests on the measurement factors, the PEP-introduced group showed a significant change ($p < 0.01$) from the first to the second measurement. Additionally, both groups showed significant changes ($p < 0.01$) from the first to the third measurement, while the PEP-unintroduced group showed significant change ($p < 0.01$) from the second to the third measurement.

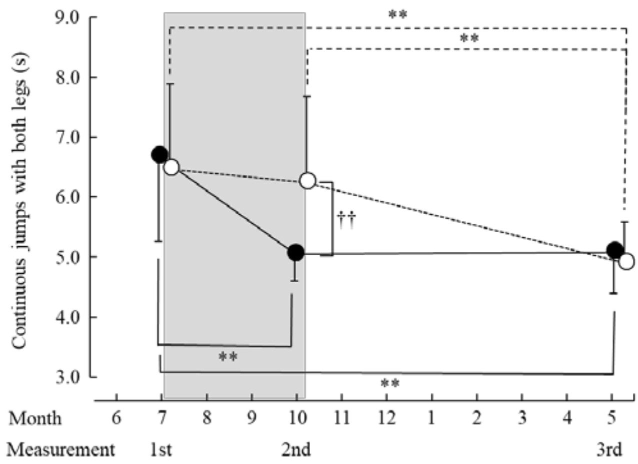

Figure 7. Changes in Continuous Jumps with Both Legs from the First to the Third Measurement in the PEP-introduced Group (Black Circles) and the PEP-unintroduced Group (White Circles)
Values are Mean ± SD.
: PEP Introduction Period
**: p < 0.01; ††: p < 0.01

Figure 8 shows changes in the one-leg beam balance from the first to the third measurement for both groups. In the PEP-introduced group, the first measurement was 2.46 ± 0.696 s, the second 5.98 ± 4.286 s, and the third 4.88 ± 2.903 s. In the PEP-unintroduced group, the first measurement was 5.04 ± 3.778 s, the second 4.07 ± 2.046 s, and the third 6.97 ± 5.711 s.

As a result of the simple main effect test, the group factor was significant ($p < 0.05$) in the first measurement. However, there was a significant difference ($p < 0.05$) in the variance between the two groups in the first measurement. Thus, as in continuous jumps with both legs, the result of Welch's t-test was adjusted by Bonferroni's method, revealing a significant ($p < 0.05$) difference between the two groups.

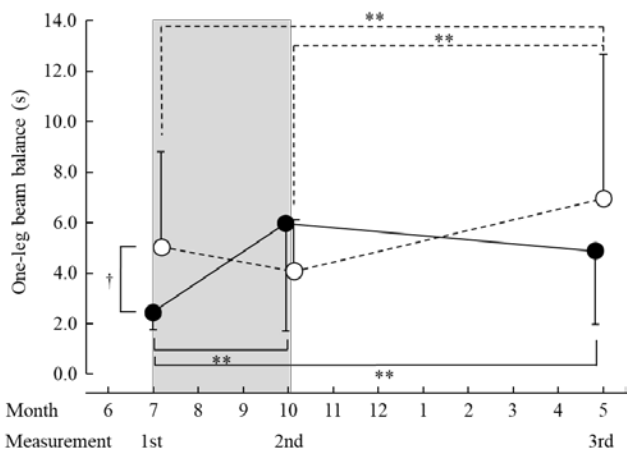

Figure 8. Changes in One-leg Beam Balance from the First to the Third Measurement in the PEP-introduced Group (Black Circles) and the PEP-unintroduced Group (White Circles)
Values are Mean ± SD.
: PEP Introduction Period
**: p < 0.01; †: p < 0.05

Additionally, the simple main effect test revealed that the measurement factor was significant ($p < 0.01$) in each group. The PEP-introduced group showed a significant difference ($p < 0.01$) between the first and the second measurement when a multiple comparison test was run on the measurement factor. Additionally, both groups showed substantial changes ($p < 0.01$) from the first to the third measurement, while the PEP-unintroduced group showed significant changes ($p < 0.01$) from the second to the third measurement.

Figure 9 illustrates differences in toe muscle strength between the two groups from the first to the third measurement. In the PEP-introduced group, the first measurement was 3.48 ± 0.831 kg, the second 5.03 ± 1.066 kg, and the third 4.80 ± 1.391 kg. In the PEP-unintroduced group, the first measurement was 4.46 ± 1.193 kg, the second 5.05 ± 1.364 kg, and the third 5.55 ± 1.413 kg.

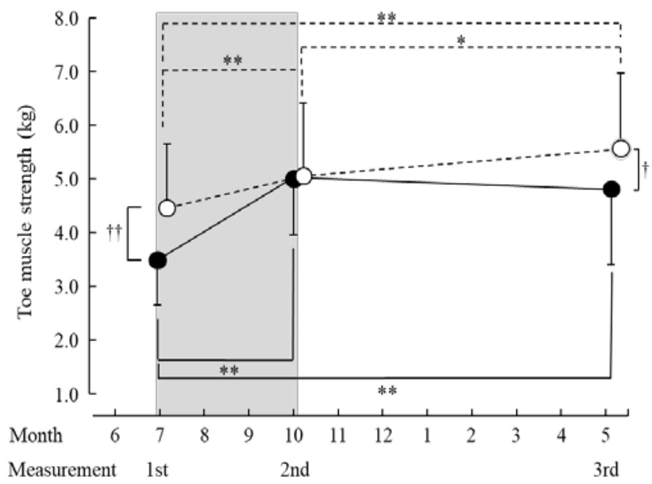

Figure 9. Changes in Toe Muscle Strength from the First to the Third Measurement in the PEP-introduced Group (Black Circles) and the PEP-unintroduced Group (White Circles)
Values are Mean ± SD.
: PEP Introduction Period
*: p < 0.05; **: p < 0.01; †: p < 0.05; ††: p < 0.01

The simple main effect test showed the group factors to be significant ($p < 0.01$ and $p < 0.05$) in the first and third measurements, and the measurement factor was significant ($p < 0.01$) in each group. The measurement factor showed significant changes ($p < 0.01$) between the first and second measurements in both groups when a multiple comparison test was run. Additionally, significant changes ($p < 0.01$) were seen from the first to the third measurement in both groups, and significant changes ($p < 0.05$) were seen from the second to the third measurement in the PEP-unintroduced group.

3.3. Increase from First to Second Measurement

Both groups showed significant increases from the first to the second measurement for body height, body weight, standing long jump, and toe muscle strength. These findings led to comparison of these four items' growth levels between groups from the first to the second measurement. In the PEP-introduced group, the change in body height from the first to the second measurement was 1.92 ± 2.33 cm, and in the PEP-unintroduced group, it was 3.08 ± 2.92 cm, with no significant difference between groups. The increased body weight from the first to the second measurement was 0.547 ± 0.313 kg in the PEP-introduced group and 0.560 ± 0.523 kg in the PEP-unintroduced group, with no significant difference between groups.

Figure 10 depicts increases in the standing long jump from the first to the second measurement in both groups. During this period, the increases were 17.9 ± 11.0 cm in the PEP-introduced group and 5.57 ± 12.1 cm in the PEP-unintroduced group. This between groups difference was statistically significant ($p < 0.01$).

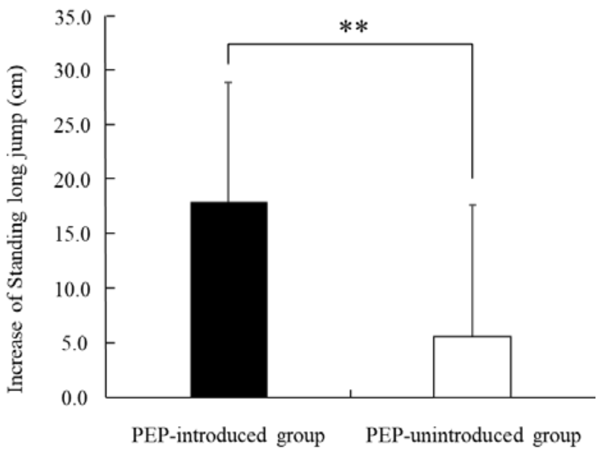

Figure 10. Comparison Between Groups of Increased Standing Long Jump from the First to the Second Measurement
Values are Mean ± SD.
**: $p < 0.01$

In both groups, the toe muscular strength increased from the first to the second measurement. Figure 11 shows that the rise was 1.542 ± 0.767 kg in the PEP-introduced group but 0.596 ± 1.249 kg in the PEP-unintroduced group, there is a statistically significant difference ($p < 0.01$) between groups.

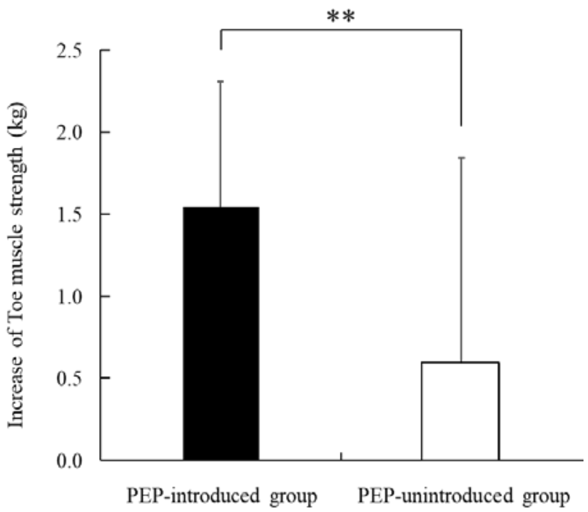

Figure 11. Comparison Between Groups of Increased Toe Muscle Strength from the First to the Second Measurement
Values are Mean ± SD.
**: $p < 0.01$

4. Discussion

Before PEP's introduction, nursery-type children (PEP-introduced group) performed worse on three of the four motor ability and physical fitness tests than kindergarten-type children (PEP-unintroduced group). The exception was continuous jumps with both legs. Consistent with a previous study [2], this study reported that nursery children who received long-time care showed less developed motor ability than kindergarten children who received short-time care. The earlier study [2] explained that kindergarten children's motor skills are superior to those of nursery school children because institutions' physical environments differ, with nurseries frequently having smaller playrooms and gardens than kindergartens, thus allowing less space for exercise-play. However, another reason might be the amount of care time. We hypothesize that nursery children who received long-time care lacked activities involving physical exercise and/or that kindergarten children who received brief care take sports lessons or have physical play time after returning home [2,22].

In this study, we introduced PEP to the nursery-type children who tended to show lower motor ability and physical fitness as described above. The effect is discussed below.

Body height and weight were not found to be affected by PEP. However, compared to the kindergarten-type children who were not exposed to PEP, the continuous jumps with both legs and the one-leg beam balance improved in the nursery-type children introduced to PEP before and after the PEP introduction period. Additionally, both groups of children had increases in their standing long jump and toe muscle strength, although the effect (degree of gain) was greater in the nursery-type children introduced to PEP than the kindergarten-type children who were not. These findings reveal that PEP's introduction positively impacted all four measures of motor ability and physical fitness.

Zeng, N. et al. [6] found that of the 10 studies assessing the effects of physical activity on preschool children's motor skills, eight (80%) reported significant improvements in motor performance. Among these eight reports, relatively new documents include reports by Laukkanen, A. et al. [4] and by Adamo, K. B. et al. [5]. The study by Laukkanen, A. et al. examined the effects of counseling for parents and did not look at the effects of exercise instruction in institutions. Adamo, K. B. et al. reported that a 6-month exercise program delivered by trained childcare providers improved fundamental movement skills in preschool children. The study by Adamo, K. B. et al. targeted preschool children in childcare centers in Canada, while our study targeted nursery children of an ECEC in Japan. The study by Adamo, K. B. et al. and our study showed similar results despite differences in country, institution, and measurement content. An exercise program of 3 months or more conducted by an instructor with sufficient knowledge may be effective in improving preschool children's motor ability and physical fitness, even with differences in the type of preschool children, and the measurement items and methods.

Seven months following PEP's introduction, both groups' body height and weight increased because of their development. Regarding the four items indicating motor ability and physical fitness, the nursery-type children introduced to PEP did not show any change; the kindergarten-type children who were not introduced to PEP improved through their development. Regarding relative superiority between two types of children in motor ability and physical fitness, the nursery-type children was inferior or equivalent before the PEP intervention. The PEP improved the nursery-type children's motor ability and physical fitness. However, 7 months after PEP cessation, the superiority returned to the level prior to the PEP intervention. Thus, 7 months following PEP's introduction, the effect of PEP disappeared.

We believe that examining how children's motor ability and physical fitness change once the exercise program ends is important. However, previous studies have not conducted such examinations. Our findings imply that PEP's impact steadily diminishes following its conclusion, when efforts are not made to continue PEP-like activities even if an instructor encourage children to spontaneous exercise-play.

Early childhood is a time of extraordinary nervous system development, which contributes to noticeable improvement in ability to regulate movement. During this period, therefore, experiencing a variety of play that includes physical exercise is important [12]. Thus, an ECEC should prepare physical and human environments to encourage and allow children's voluntary physical activity. In addition to expanding the institution's garden and play area, which would improve the physical environment, appointing "supporters of play" who offer ways to exercise-play and who occasionally join the fun is necessary [23].

For 3 months, we introduced PEP to nursery-type children in an ECEC to enhance the human environment mentioned above. An external instructor with sufficient knowledge of exercise for preschool children led the program. She provided methods of exercise-play and encouraged the children to become companions in play. The study confirmed that PEP's introduction effectively improved the children's motor ability and physical fitness. Nevertheless, these effects had clearly disappeared 7 months after PEP activities' cessation.

The Japanese Ministry of Education, Culture, Sports, Science and Technology [24] states that preschool children acquire a variety of movements through spontaneous play with exercise, that their movements are refined through repetition, and that play leaders have an important role in eliciting children's desire for exercise-play. We believe it necessary to assign quality instructors and incorporate exercise-play into childcare programs to improve preschool children's motor ability and physical fitness.

5. Conclusion

This study found that PEP's introduction effectively improved children's motor ability and physical fitness. Clearly, however, the effects disappeared 7 months after cessation of PEP activities.

Future studies should conduct larger-scale interventions to clarify the effects of exercise-play programs provided by expert instructors on children's motor ability and physical fitness. In addition, we should investigate how children's motor ability and physical fitness change after a program's cessation. The scientific knowledge obtained should be used in childcare fields, and children's spontaneous exercise-play should be encouraged for their appropriate development of motor ability and physical fitness.

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Statements of Competing Interests

The authors have no competing interests.

List of Abbreviations

PEP: program of exercise-play

ECEC: certified Center for Early Childhood Education and Care

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