Material

Relationships between the changes of physical fitness and motor ability and playing in kindergarten children - Study on children in “A” kindergarten in Okayama prefecture -

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In this study, we analyzed and compared the results of physical fitness and motor ability tests conducted on children enrolled at “A” kindergarten as well as surveys of children’s playing. The subjects were 115 boys and girls enrolled in “A” kindergarten between 1995 and 2005. We measured the height, weight, 25-m dash, ball throwing, hanging from a bar, standing broad jump, and standing on one leg. The results were as follows:
1) There were no significant differences between the results of 1995 and 2005 in the overall height or weight of the boys and girls. There were no significant differences among various time periods in the height or weight of the girls and boys separately.
2) In all the boys and girls, there were no differences in the 25-m dash, ball throwing, and hanging from a bar. The children’s standing broad jump in 2005 (106.5±18.0 cm) was significantly shorter ($p<0.01$) than that in 1995 (117.9±16.7 cm). The children’s standing on one leg in 2005 (48.5±51.8 sec) was also significantly shorter ($p<0.01$) than that in 1995 (98.4±97.0 sec).

In conclusion, the results for the standing broad jump and standing on one leg continued to decrease chronologically, and we believe that concrete measures are essential to encourage proper growth and development.

Key words : infant, physical fitness, motor ability, playing

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1. Introduction

In general, physical fitness (performance fitness) can be classified into the following components: muscle strength, instantaneous force, muscle endurance, physical endurance, and coordination ability (agility, balance, flexibility, and accuracy). Preschool age children are in the rapid development phase of the cerebral nervous system on the Scammon’s growth curve. Development of the nervous system is thought to be deeply related to the development of coordination ability (balance, agility, and accuracy), a component of physical fitness. Therefore, young children are supposed to be more suited to light-intensity exercise with various motions than exercise that requires intensive strength or that depends on cardio-respiratory capacity. In recent years, changes in the social environment surrounding children have been contributing to a reduction of opportunities for children to engage in exercise. For instance, Inoue (1998) has reported a decrease in amount of exercise in kindergarten children based on his survey of step counts. According to Masuoka et al. (2003), this lowering tendency of step counts in children is attributable to a decrease in range of motion and in outdoor play/ activities in their daily lives. It is hard to think that such a life environment surrounding young children promotes development of their physical fitness/ motor ability, including coordination ability.

Ministry of Education, Culture, Sports, Science and Technology (MEXT) administers an annual physical fitness test in order to clarify current status of physical fitness/ motor ability in Japanese and to acquire basic data for use in physical education and administration (MEXT,

2000). This test serves as the standard for physical fitness tests in Japan. Since preschool children are not included in its target population, however, changes in their physical fitness/ motor ability have not been sufficiently surveyed at the national level. The MEXT test is intended to evaluate the following physical fitness components: muscle strength, muscle strength/ endurance, flexibility, agility, physical endurance, muscle power (instantaneous force), speed/running ability, and muscle power (instantaneous force)/ throwing ability/ accuracy. As shown, no components related to balance are evaluated. Considering characteristics of physical development in preschool children, it is also important to evaluate balance ability as an index of evaluation of physical fitness/ motor ability.

Akimaru (2003) investigated the status of and problems with physical fitness in young children through the results of a physical fitness test consisting of 10 items to measure quantitative (e.g., time, distance) motor ability (20-meter dash, standing broad jump, tennis ball throw, side-to-side jumping, hopping on one foot, rope jumping, pull-ups, standing on one foot, ball bouncing, and leaping & ducking) and 6 items to measure qualitative motor ability as achievement rates (target hitting with a tennis ball, turning around on a bar, ball kicking, tennis ball catching with both hands, handsprings, and jumping with legs apart).

In actuality, however, it is difficult to examine children for all 16 test items. Currently, kindergartens choose certain items depending on their respective situations when they conduct physical fitness tests on children. This situation is reflected in a declining number of reports on the development of physical fitness/ motor ability in young children based on large samples (Demura et al., 2005). Play in early childhood is surveyed mainly through observation records and questionnaires for instructors for children such as nursery teachers. However, no researchers have clarified the relationships among annual changes in physical fitness/ motor ability and those in play in preschool children.

In this study, therefore, data on physical fitness/ motor ability tests conducted in a kindergarten were analyzed in order to clarify changes in physical fitness/ motor ability in preschool children over a period of 10 years. Furthermore, the data were compared with the results of preceding studies on lifestyles (including play) of children to reveal relationships between play (especially physical play) and development of physical fitness/ motor ability in preschool children.

2. Methods

2.1. Subjects

The subjects of this study were 115 boys and girls enrolled in “A” Kindergarten in 1995 and 2005. They consisted of 53 children enrolled in 1995 (26 boys and 27 girls) and 62 children enrolled in 2005 (31 boys and 31 girls). Data were recorded when the individual subjects were enrolled in the 5-year-old classes of this kindergarten. It should be noted that members of a 5-year-old class in a kindergarten inevitably include 6-year-old preschool children. Data on those who were unable to participate in all test categories for various reasons such as illness on test days were excluded from the data used for analysis.

2.2. Measurement Items/ Methods

As physical characteristics, body height and weight of the subjects were measured. Measurement of physical fitness/ motor ability was conducted in November in 1995 and 2005. This measurement consisted of 5 items; namely, 25-meter dash, ball throwing, hanging from a bar, standing broad jump, and standing on one foot. Measurement methods for the respective test items were as follows:

- 25-meter dash: The time required for subjects to run a 25 meter straight sprint was measured. Measurement was conducted twice and the faster time was recorded to the nearest one-tenth of a second.
- Ball throwing: The distance subjects could throw a tennis ball was measured. Measurement was conducted twice and the better result was recorded to the nearest 10 centimeter.
- Hanging from a bar: The length of time subjects could hang from a bar was measured. Measurement was conducted once only and the result was recorded to the nearest one-tenth of a second.
- Standing broad jump: Subjects were required to take off and land using both feet. Jump distance was measured. Measurement was conducted twice and the better result was recorded to the nearest one centimeter.
- Standing on one foot: The time subjects could stand on

one foot with eyes open was measured. Subjects were allowed to stand on whichever foot they preferred. Measurement was conducted once and the result was recorded to the nearest one second.

2.3. Statistical Processing

Stat View5.0 was used as statistical software. Due to the smallness of sample size, use of parametric methods was likely to fail to produce normal statistic distribution. Therefore, a comparison by year was conducted with use of a nonparametric test (Mann-Whitney test). The level of statistical significance was set at under 5%.

3. Results

3.1. Physical Characteristics

Tables 1, 2, and 3 show the physical characteristics of the subjects. Concerning body height and weight, no significant difference was observed between children of both sex enrolled in 1995 and in 2005. Also in a comparison by sex of body heights and weights, no significant difference was observed between these 2 groups.

Table 1. Physical characteristics by age (children of both sexes)

Year	n	Height(cm)	Weight(kg)
1995	53	113.2±4.7	19.6±2.3
2005	62	113.3±5.0	19.4±2.7

Table 2. Physical characteristics of boys

Year	n	Height(cm)	Weight(kg)
1995	26	114.2±4.7	20.0±2.2
2005	31	114.1±4.7	19.6±2.5

Table 3. Physical characteristics of girls

Year	n	Height(cm)	Weight(kg)
1995	27	112.2±4.5	19.1±2.4
2005	31	112.5±5.0	19.1±2.7

3.2. Physical Fitness/ Motor Ability

Table 4 shows the analysis results of the physical fitness/ motor ability test in children of both sexes. There were no significant differences between the 2 groups of children in terms of the results of 25-meter dash, ball throwing, and hanging from a bar. Concerning the standing broad jump, the mean value of the 2005 group (106.5 ± 18.0) was significantly lower than that of the 1995 group (117.9 ± 16.7) ($p < 0.01$). Concerning standing on one foot, the mean value of the 2005 group (48.5 ± 51.8) was significantly lower than that of the 1995 group (98.4 ± 97.0) ($p < 0.01$).

Tables 5 and 6 show the analysis results by sex of the physical fitness/ motor ability test. There were no significant differences between boys in the 2 groups in terms of the results of 25-meter dash, ball throwing, and hanging from a bar. Concerning the standing broad jump, the mean value of the boys in the 2005 group (113.9 ± 18.5) was significantly lower than that of the boys in the 1995 group (124.0 ± 14.5) ($p < 0.05$). Concerning standing on one foot, the mean value of the boys in the 2005 group (38.1 ± 49.1) was significantly lower than that of the boys in the 1995 group (104.9 ± 118.5) ($p < 0.01$). There were no significant differences between girls in the 2 groups

Table 4. Results of the physical fitness/ motor ability test (children of both sexes)

Year	n	25m dash (sec.)	Ball throwing(m)	Hanging from a bar (sec.)	Standing broad jump (cm)	Standing on one foot (sec.)
1995	53	6.5±0.6	7.6±4.2	103.2±91.5	117.9±16.7	98.4±97.0
2005	62	6.6±0.6	6.5±2.5	79.4±65.6	106.5±18.0**	48.5±51.8**

mean±SD,**p<0.01, vs. 1995

in terms of the results of 25-meter dash, ball throwing, hanging from a bar, and standing on one foot. Concerning the standing broad jump, the mean value of the girls in the 2005 group (112.1 ± 16.8) was significantly lower than that of the girls in the 1995 group (99.2 ± 14.3) ($p < 0.01$).

4. Discussion

4.1. Physical Fitness/ Motor Ability

Preschool children are in a phase of physical development represented by basic physical activities such as walking, jumping, running, throwing, and catching. They are also in a phase of cerebral and nervous development, including growth of sensation and development of nerve/ muscle control ability. Miyamura (1998) identified age-related stages of development of motor ability during the period from birth to the time that sports skills are acquired. According to him, children at 5 years of age are in a stage where various basic motor patterns rapidly develop to form the basis of motor ability required throughout life. In other words, motion experience in this period of life is supposed to have a significant effect on physical development in later life.

In a comparison of kindergarten children in the 1995 group and in the 2005 group in this study, significant differences were observed in the standing broad jump and standing on one foot but not in the 25-meter dash, ball throwing, and hanging from a bar. Based on the results of their nationwide survey in young children, Kondo et al. (1998) reported that the level of physical fitness/ motor ability in children examined in 1997 was statistically significantly lower than that in children examined in 1987 in all test items.

Similarly, Sugihara et al. (2004) reported based on their nationwide survey that no stable tendencies were recognized in overall changes in the physical fitness/ motor ability over 20 years from 1966 to 1986 and that a declining tendency was observed in all test items during the 10-year period from 1986 to 1997.

The results of this study confirmed a continuation of this declining tendency up to 2005. Many researchers have concluded that the physical fitness/ motor ability of elementary school children/ junior high school children reached a peak around 1985 and that it has been declining since then (Kagaya, 1996; Wakita, 1996; MEXT, 2006). From these reports, it can be assumed that level of physical fitness/ motor ability has been decreasing in a wide range of age groups from young children and that measures should be taken to reverse this tendency.

It is said that physical constitution, such as body height, affects levels of physical fitness/ motor ability (Ito et al., 1989). Since there were no significant differences in body height/ weight between the 1995 group and the 2005

Table 5. Results of the physical fitness/ motor ability test in boys

Year	n	25m dash (sec.)	Ball throwing(m)	Hanging from a bar (sec.)	Standing broad jump (cm)	Standing on one foot (sec.)
1995	26	6.4±0.5	9.8±5.0	122.6±118.0	124.0±14.5	104.9±118.5
2005	31	6.3±0.5	7.8±0.2	87.0±68.3	113.9±18.5 *	38.1±49.1 **

mean±SD,**p<0.01,*p<0.05, vs. 1995

Table 6. Results of the physical fitness/ motor ability test in girls

Year	n	25m dash (sec.)	Ball throwing(m)	Hanging from a bar (sec.)	Standing broad jump (cm)	Standing on one foot (sec.)
1995	27	6.6±0.6	5.4±1.4	84.6±51.3	112.1±16.8	92.1±72.3
2005	31	6.8±0.6	5.2±1.3	71.6±63.6	99.2±14.3 **	59.0±53.2

mean±SD,**p<0.01, vs. 1995

group in this study, however, this seemed to have little effect on the results.

Standing broad jump is a test item that measures muscle power (instantaneous force), a component of physical fitness. This component is expressed as the product of muscle strength and speed with some involvement of accuracy (MEXT, 2000). In this study, no significant tendency of decrease was observed in the 25-meter dash, an index of speed, hanging from a bar, an index of upper-body muscle strength, and ball throwing, an index of accuracy. It was considered, therefore, that a decrease in leg (lower-body) muscle strength affected the standing broad jump ability.

Sato (1983) investigated the effect of physical play on the development of motor ability in children of 4-5 years of age and reported that development of instantaneous force was greatly affected by physical play. Studying the effect of training on running ability in elementary school children, Miyamaru et al. (1990) reported that improvement was observed in leg muscle power and standing broad jump in children after training. It can be said that physical play including running contribute to development of instantaneous force.

The Benesse Educational Research and Development Center conducted a survey on varieties of play in preschool children (2006). As a result, the rates of children engaging in "outdoor play (e.g., tag, kick-the-can)"and/ or "rope jumping/ rubber band rope jumping," which are thought to contribute to the development of leg muscle power, in 2005 were slightly higher than those in 1995, while the rates were low on the whole for both years. Kubo et al. (2007) reported the results of a survey they conducted in 2005 in which the rate of children engaging in TV watching was higher than the rate of children engaging in outdoor play.

From these reports, it was assumed that children were no longer choosing physical play involving in running motion (e.g., running after/ away from playmates, sudden stopping/ starting) and jumping motion (e.g., leaping over obstacles, rope jumping), in addition to a decrease in outdoor play had caused a decrease in leg muscle force in children.

Standing on one foot is an item that measures balance, an important ability which serves as the basis of physical exertion. Young children aged 4-6 are in the transitional phase of posture control, during which they begin to acquire the ability to integrate/ modify visual input, proprioceptive input, and vestibular input, which are necessary for posture control (Yabe, 1994). In terms of the development of motion in the posture control system, experience in childhood has a lifetime effect on the individual. Therefore, a decrease in balance ability can be a critical issue.

In this study, the mean value of standing on one foot in the 2005 group was significantly lower than the corresponding value in the 1995 group. From the results of earlier studies (Sato, 1983; Naka et al., 2006) demonstrating that physical play had a marked impact on the development of balance ability in preschool children, it is assumed that balance ability is nurtured during physical play.

According to a report from the Benesse Educational Research and Development Center (2006) on varieties of play in children, "Play with use of bicycle/ unicycle/ tricycle," which are thought to contribute to the development of balance, accounted for 53.9% in 2005 and 46.3% in 1995, showing a slightly increasing tendency. It should be noted, however, that varieties of play other than physical play with dynamic use of the body ranked in high as shown in the following percentages; play with blocks: 63.1%, drawing: 57.5%, and playing house: 56.9%.

While the rate of children engaging in physical play that contributes to development of balance tended to increase, children engaging in static indoor play accounted for the highest percentage of all the children surveyed. Insufficient development of physical manipulation ability was considered to cause an overall decrease in balance ability. Development of coordination in preschool children is related to amount of physical exertion. The higher the daily step count in children, the higher the total scores for coordination ability (Shimizu et al., 2006).

Inoue (1998) conducted a step count survey in kindergarten children which revealed that the amount of physical exertion in kindergarten children had reduced. From these reports, it is thought that children are not securing a sufficient amount of physical exertion and that this may be related to a decrease in the amount of physical exertion.

Since lifestyle habits, such as sleep, are also supposed to have an impact on physical fitness/ motor ability (Tanimoto et al., 2006), further research should be conducted in consideration of this issue.

4.2. Educational Concerns

According to a report by the Benesse Educational Research and Development Center (2006) on changes in play environment over 10 years from 1995 to 2005, children who played mainly at home accounted for 76.6% in 1995 and 55.1% in 2005. Percentages of children who played in their neighborhood, at local parks, schools, or playgrounds of kindergartens/ nursery schools were also higher in 2005 than in 1995. These results indicated that number of children who played outdoors increased over the previous 10 years.

Preschool children who mainly play outdoors have higher motor ability than those who mainly play indoors (Sugihara et al., 1999). Outdoor play is thus important for development of motor ability. Considering the fact that physical fitness tends to decrease in spite of an increase in outdoor play, however, it may be necessary to study the content of play. There is a particular concern about a continuous decrease in balance ability, which is related to the development of the nervous system.

Ohtsuki (2003) showed 3 abilities in individuals who were excellent in balancing, one of which was reflex function. According to Ohtsuki, efficient postural reflex paths are formed by sufficient experience of external stimulation that disturbs posture. From the viewpoint of history of mankind, Satake (1998) made the analogy that physical activities or exercises have been effective for healthy and normal physical development in humans. Thus, physical play/ experience (especially outdoor play) is indispensable for appropriate growth in children.

As practical measures, it is important to adopt basic physical motions; namely, walking, running, jumping, and throwing, for physical play. Of these, walking is the most basic exercise for humans. It is necessary for caregivers to actively provide young children with opportunities for walking and outdoor play in order to increase the amount of physical activity in children.

It is also important to incorporate physical play related to coordination ability in children's play. Considering a declining tendency of ability of balance, physical play that requires balance is especially meaningful. Physical play to train ability of balance includes unicycle/ bicycle riding, stilt walking, hopping, and skiing. It is hoped that caregivers will develop a suitable curriculum that helps children to enjoy such activities.

Ozawa (2007) compared the respective levels of improvement of physical fitness in children when improving lifestyle, lifestyle and school activities, and lifestyle, school activities, and community activities. As a result, amount of physical activities and level of physical fitness in children were the highest when lifestyle, school activities, and community activities were all improved. Therefore, it is important for families, kindergartens, and the community to work together to enhance physical fitness/ motor ability in preschool children.

5. Conclusion

In this study, changes in physical fitness/ motor ability in preschool children over a period of 10 years were clarified through an examination of data from physical fitness/ motor ability tests conducted by "A" Kindergarten on 115 boys and girls in 1995 and 2005. Furthermore, the data were compared with various reports on the lifestyles (including play) of preschool children.

As a result, no significant differences were observed in body height/ weight between the 1995 group and the 2005 group. Similarly, no significant differences were observed in the 25-meter dash, ball throwing, and hanging from a bar between these 2 groups. Regarding the standing broad jump and standing on one foot, the mean value in the 2005 group was significantly lower than that in the 1995 group.

While the rate of children engaging in outdoor play was slightly higher in the 2005 group than in the 1995 group, children who played outdoors accounted for approximately half of all children surveyed. It was supposed that a high rate of engagement in play which required little physical exertion caused a decrease in instantaneous force and balance.

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References

Akimaru, T.(2003) Changes and problems in the physique and athletic ability of infants over 30 years [in

Japanese]. Child Growth and Development [in Japanese]. 1, 2, 128-132.

Benesse Educational Research and Development Center (2006) Third survey of questionnaire on daily life of children [in Japanese]. Research Report 35, 57-63.

Demura S., and Murase, T.(2005) Scientific Approach of Physical Fitness and Motor Ability on Children – Theory and Practice of Test and Measurement [in Japanese]. NAP Limited.

Inoue, T.(1998) Changes in children seen from walking survey [in Japanese]. Research Journal of Walking 2, 67-73.

Ito, k., Amano, H., Kuwabara, N., and Ichijima, N.(1989) A Longitudinal Study on Developments of Motor Abilities in Childfood (Part5) [in Japanese]. Bulletin of Tokai Women's Junior College 15, 105-112.

Kagaya, A.(1996) Physique and strength of children today [in Japanese]. Journal of Physical Education 4, 18-21.

Kondo, M., Sugihara, T., Mori, S., and Yoshida, I.(1998) Motor ability of recent preschool children [in Japanese]. Journal of Hhealth, Physical Education and Recreation 48, 10.851-859.

Kubo, T., Igari, Y., and Noda, K.(2007) Research on life and play in infancy: On the “lack of three elements ” phenomenon from kindergarteners’ play after school [in Japanese]. The Faculty of Humanities and social sciences of Jissen Women's University annual reports of studies 3. 1-18.

Ministry of Education (Ministry of Education, Culture, Sports, Science and Technology) (2000) New physical fitness test – for meaningful application [in Japanese].

Ministry of Education, Culture, Sports, Science and Technology (2006) Reports, on the survey of physical fitness and athletic ability in 2005 [in Japanese].

Masuoka, Y., and Nishimura, M.(2003) Exercise Play a la carte [in Japanese]. Tokisyobou [in Japanese].

Miyamaru, M.(1998) Balanced development of athletic ability [in Japanese]. Journal of Health, Physical education and recreation 48, 9.699-705.

Miyamaru, M., and KATOH, K.(1990) Development of running ability with growth [in Japanese]. Journal of Health, Physical Education and Recreation 40, 10.775-780.

Naka, T., and Ookawachi, C.(2006) A Report of Development Physical Activities in Children Three to Five Years Old with Play Exercise [in Japanese]. Bulletin of the Center for Educational Research and Training 16, 117-126.

Ozawa, H.(2007) Vision of a physical education curriculum from the developmental stage of childhood [in Japanese]. Journal of Physical Education 5. 14-17.

Ohtsuki, T.(2003) Nerves that control balance, Journal of Health [in Japanese]. Journal of Health, Physical Education and Recreation 53, 4.236-240.

Satake, T.(1998) Developmental balance of the cardiorespiratory system [in Japanese]. Journal of Health, Physical Education and Recreation 48, 9.712-716.

Sato, K. (1983) A Study on the Development of Motor Ability in Infants : Effects of Infant's Practice in Exercises [in Japanese]. Bulletin of the Faculty of Education, Hirosaki University 50, 61-71.

Shimizu, S., Muraoka, Y., Nhida, M., Ohmori, F., Suzuki, I., Okada, T., Sasaki, R., and Kagaya A.(2006) Relationship between the development of coordination ability and physical activity in children. Bulletin of the Keio University Institute of Physical Education 45, 1-6.

Sugihara, T., Kondo, M., Mori, S., and Yoshida, I.(1999) Criteria for evaluating athletic ability of infants and the relationship of kindergarten/home environment and play to motor development [in Japanese]. Journal of Health, Physical Education and Recreation 49, 5. 427-434.

Sugihara, T., Mori, S., Yoshida, I., and Kondo, M. (2004) Infant athletic ability as seen in the 2002 national survey [in Japanese]. Journal of Health, Physical Education and Recreation 54, 2. 161-170.

Tanimoto, M., and Harada, M.(2006) Research on Our Lifestyle (3): A Study of Rhythm of Sleep and the Sense of Equilibrium in Infants [in Japanese]. Journal of Chugokugakuen 5,137-140.

Wakita, H. (1996) Children’s physical strength has declined this much now [in Japanese]. Journal of Health, Physical Education and Recreation 46, 286-291.

Yabe, K.(1994) Posture and development [in Japanese] Journal of Health, Physical Education and Recreation 44, 1.31-37.