

原 著

Acquisition process of unsupported sitting-up in motor development of infants in Japan

乳児の運動発達における座位獲得過程の現状調査

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Abstract

According to Pikler's comprehensive observations of developmental milestones, most of infants become able to sit up unsupported after they began creeping on the ground. In Japan, the acquisition of sitting has been adopted as one of the important developmental indicators of infants. The age of acquisition of sitting-up of infants and its individual differences have been reported in previous research; however, the acquisition process has not been well investigated for infants after Pikler's observations during 1940s-1960s. The present study investigated the process of acquiring the sitting posture from creeping and crawling in infants, by a questionnaire collected from 260 Japanese parents in 31 nursery school in three prefectures (Hyogo, Okayama and Tottori) of Western Japan. The results showed that 61.2% of infants sat up unsupported earlier than they began creeping or hands-and-knees crawling. The study further revealed that cultural reasons and parents' misinterpretation of the definitions regarding milestone postures advised by the current governmental handbook for mother and child health may attribute to the reversal of these two major milestone sequences in the case of Japanese infants. We propose that a revision of the related mother-child handbook with appropriate words of motor developmental milestones with their clear definitions is recommended. This study also suggests the needs of further investigations of the effects of environmental factors related to the spontaneous movement of infants, such as the use of infant equipment, on motor development of infants.

Key words : infant, milestones, motor development, sitting posture, medical checkup

乳児, マイルストーン, 粗大運動, 座位姿勢, 発達検査

Introduction

Research on early developmental milestones in infants has increased in recent years due to the academic recognition of their importance in predicting disability (Dosman et al., 2012) and cognitive achievements (Adolph and Franchak, 2018; Thelen, 2000). If the infant does not play well in the prone position before gaining walking, it is also

possible that it will lead to delays in motor development (Tanaka et al., 2010).

In the 20th century Dr. Emmi Pikler, an Austro-Hungarian pediatrician, established the foundation for the approach of providing free space to infants for self-development, which would lead to better resilience throughout life (Pikler, 1970). According to Pikler, modern parenting methods, which tend to restrict free movements of infants, may often result

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in children lacking self-competence and growing up dependent on parental help. Subsequently, Pikler (1972) modified the traditional model of Sherley and Gesell (Gesell, 1939 ; Sherley, 1933) to establish a new theory of the sequence of developmental milestones. In Pikler's milestone sequence (Pikler, 1972), creeping is usually followed by unsupported sitting (**Fig. 1**). Pediatricians divide infant sitting into three stages, generally screened at medical checkups as "pulls to sit" (sitting pulled up and supported by an adult) at about 6 months of age, "sits well" (sitting with your legs out and without supports by other persons) at about 9 months, and "gets to sit" (sitting-up unsupported) at about 12 months (Dosman et al., 2012). Most studies to date have observed only stationary sitting postures such as a milestone in the sitting-up unsupported stage of infant development. This is because the stage substantially means the acquisition of a sitting posture without the help of another person, while they are getting a standing posture. However, the movement during the postural changes from creeping and crawling to sitting cannot be ignored (Kimura-Ohba, 2011). Although there is no report of the potential effect of the crawling-to-sitting process on acquisition of following motor skills after walking, we consider the infants' own spontaneity should be respected as Pikler recommendations. Note that the spontaneous interactions of infants with their surrounding objects depend on the posture variation after acquisition of crawling or sitting (Thurman and Corbetta, 2019). Further, the ample spontaneous activity is essential for the development of the nervous system to adapt motor behavior in their later life (Hadders-Algra, 2018). Thus, it is desirable to respect this movement as the infants' learning to resist gravity, and to position it as an

independent learning process for the infant, even if it is temporary.

As observed in Jamaica (Hopkins and Westra, 1990) and Kenya (Super, 1976), certain cultural parenting practices can alter or reverse the order of acquisition of the two milestones, creeping and sitting-up unsupported. In another African country, Uganda, infants are often trained from early age, and "by five months all tested could sit (unsupported) for half an hour or more" (Landreth, 1967). In this observation, there is a high rate of creeping and sitting appearing in reverse trends at developmental milestones, with reports of 86% of infants sitting unsupported before beginning to creep. This high number of cases may be due to cultural and other environmental factors that may have altered the order of infants' acquisition of motor ability from the general order of milestones. The ages at which infants are able to crawl and sit up unsupported reported since 1940s in several countries are summarized in **Table 1**. Previous studies suggests the reverse order of acquisition of creeping and sitting-up unsupported by infants has been observed since 1990 (**Table 1**). Maekawa (1974) reported the acquisition of crawling using both hands and knees and sitting-up unsupported in the general order of milestones at about 7 and 10 months of age, respectively.

In Japan, during infant medical checkups, parents are asked whether the infants can passively maintain a sitting posture at 6-7 months of age (Ministry of Health, Labour and Welfare, 2010). In Canada, medical checkups are conducted at the same ages as in Japan: passively sitting at 6 months of age, "sits well" at 9 months, and "gets to sit" at 12 months (Dosman et al., 2012). However, the spontaneous

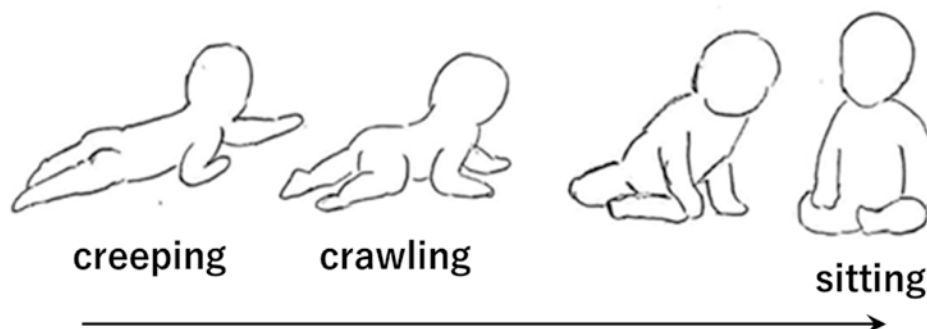


Figure 1. A part of development milestone sequence from creeping to sitting-up unsupported (Pikler 1972)

Table 1. Reported ages of infants acquiring the crawling and the sitting-up unsupported.

| Author (Year) | Region (Country) | Crawling (Mean age of months) | Sitting-up unsupported (Mean age of months) | Notes |
|------------------------------------|---------------------|----------------------------------|------------------------------------------------|---------------------|
| Gesell (1941) | USA | 9.2 | 10.1 | |
| Reviewed in Pikler (1968, 1972) | Germany | 6.4 | 7.4 | |
| | Russia | 6.9 | 7.6 | |
| | UK | 10.1 | 9.2 | Reverse sequence |
| | Russia | 6.0 | 7.8 | |
| Pikler (1968) | Hungary | 9.0 | 10 | |
| Hopkins and Westra (1990a) | Jamaica | 9.1 | 4.9 | Reverse sequence |
| Hopkins and Westra (1990b) | UK | 9.9 | 6.1 | Reverse sequence |
| WHO (2006) | international | 8.3 | 6 | Reverse sequence |
| Kalmar (2017) | Japan | 8.6 | 7.4 | Reverse sequence |

acquisition process of the motor ability from creeping and crawling to sitting-up unsupported has only been investigated by very few previous studies in Japan.

In the present study, we investigated the acquisition process of the motor development by focusing on the movements of Japanese infants during the postural change from crawling to sitting.

Methods

Preparation of questionnaire

The questionnaire was prepared in consultation with three graduate students from Hyogo University of Teacher Education (Kato city, Hyogo, Japan), a midwife and a pediatrician involved in the infant medical checkups, and an orthopedic surgeon. This consultation was finalized through a preliminary survey of 18 parents whose infants had already walked. Finally, the questionnaire was prepared with the following questions: (1) age and sex of the participants' children (sons or daughters), (2) ages and employment statuses of participants (child's parents), (3) presence of siblings, (4) family structure of living together, and residence if living together or separately, (5) age at which the child begins to use

nursery school or daycare center, (6) birth records including (6-1) gestation period, (6-2) birth body weight, and (6-3) medical history, and (7) age at which the following motor development milestones are achieved: (7-1) becoming able to hold his/her head, (7-2) turning from supine to prone position, (7-3) crawling on the back, (7-4) sitting with supported, (7-5) sitting without support (sitting-up unsupported), (7-6) bottom shuffling, (7-7) creeping, (7-8) crawling on both hands and knees, (7-9) holding on (standing up while grabbing), and (7-10) walking by himself/herself. In addition, they are asked (8) where the infants spent most of the daytime (in a carrier called hug or piggyback, on a floor or bedding/futon, or in an infant equipment) during the first six months of life, (9) where the infants did from 6 months old until he/she could walk by oneself, (10) the total number of hours of sleep per day at 6- and 12-month-old, (11) their use of infant equipment, (12) the amount of space where the infant could freely move in the house. (13) The participants' (parents') understanding of when the children acquire a sitting posture, and (14) the frequency of infant's falls within 3 months of starting to walk by oneself and the body parts that were mainly injured during these falls were also

asked. The 13th question was asked in the form of choosing an answer from the following five choices: (a) before turning from supine to prone, (b) at the same time as turning from supine to prone, (c) after turning from supine to prone, (d) after creeping and crawling, and (e) I do not know.

Subjects

The subjects were infants who were able to walk in the '0-' or '1-year-old' classes and were born in one or two years prior to their enrollment in 31 preschools, respectively, in Hyogo, Okayama, and Tottori Prefectures from September till November in 2015. The age of the target infants was set at 11 to 31 months of age during the survey period. This target setting was based on the report by the Ministry of Health, Labour and Welfare of Japan (2010) that more than 90% of children acquire walking by 16 months of age. Consent was obtained from all participants for the research use of their responses to the questionnaire. The personal response information was limited to numbers unrelated to names for analysis, and the information that could identify the individual was stored separately from the response data. This study was approved by the Ethics Committees of Hyogo University of Teacher Education as No. 7 in 2015.

Nursery school teachers were asked to help recruit participants for the study by distributing the questionnaires to parents. The request for responses was informed in a document was enclosed with the survey form of the questionnaire and additional information. In this document, we declared that the responses are anonymous and voluntary, that the response contents are statistically analyzed for research purposes, and that the personal information of the participants would be handled with care. After the distribution of the questionnaire to total of 612 parents, we received responses from 360 (58.8%). Of these 360 cases, total of 61 (11 cases diagnosed with developmental disability from pregnancy, 24 cases with low birth weight (< 2,500 g), 26 cases with preterm birth (born before 37 weeks of pregnancy), and 12 cases who started walking at 16 months of age or older; but with duplication) were excluded from the analysis because of the possibility of delayed motor skill development. In addition, 39

cases with incomplete responses that did not answer all the questions were excluded, resulting in a final number of 260 valid responses, where a valid response rate was 72.2% among 360 collected. The final valid response rate was 42.5% (260 out of 612).

Statistical analysis

Analysis was done for investigating the possible relationship between the order in which infants acquired crawling and sitting-up unsupported (responses to question 7) and their parents' understanding of when they acquire a sitting posture (responses to question 13). First, 260 children were defined as early crawling group or early sitting group according to their parents' answers to the 7th question. Children in both groups were also assigned to one of five categories (a – e) according to their parents' responses to the 13th question. The enrichment factor was defined as $(nf/n)/(Nf/N)$ to indicate the difference in the proportion of the early sitting group in each category, where nf is the number of infants in the early sitting group in the category; n is the total number of infants within the same category; Nf is the total number of infants in the early sitting group in any categories; and N is the total number of infants, 260. The significance of the difference in the proportion of the early sitting group in each category was statistically analyzed using Fisher's exact test with hypergeometric distribution. After the Bonferroni correction for multiple comparisons, the significance level was set at $P < 0.05$.

Results

In the motor development of infants after birth, it is important to observe the process of acquisition of the sitting posture, especially whether there was creeping and crawling with spontaneous movements before the infant started to sit without support in daily life. This sitting posture is the first anti-gravity posture in which the infant acquires the ability to stand and walk. When crawling was observed before sitting, it was defined as ordinary sequence, and when sitting was observed before crawling, it was as reverse sequence (Fig. 2). In this study, out of 260 parents' responses, 101 infants (38.8%) showed

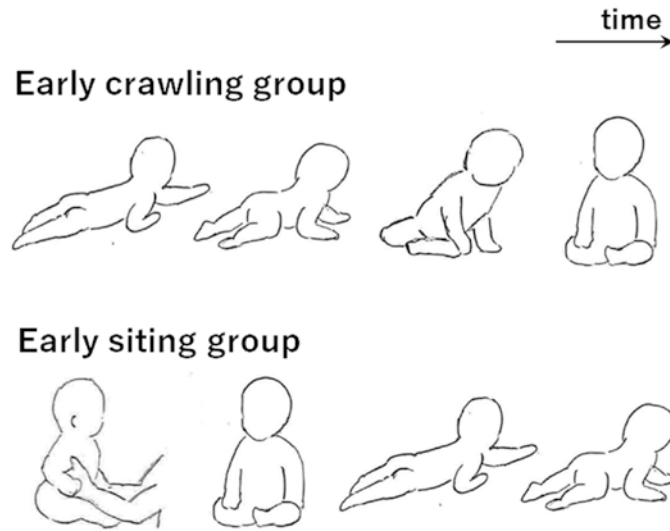


Figure 2. Definition of early crawling and early sitting groups set in this study.

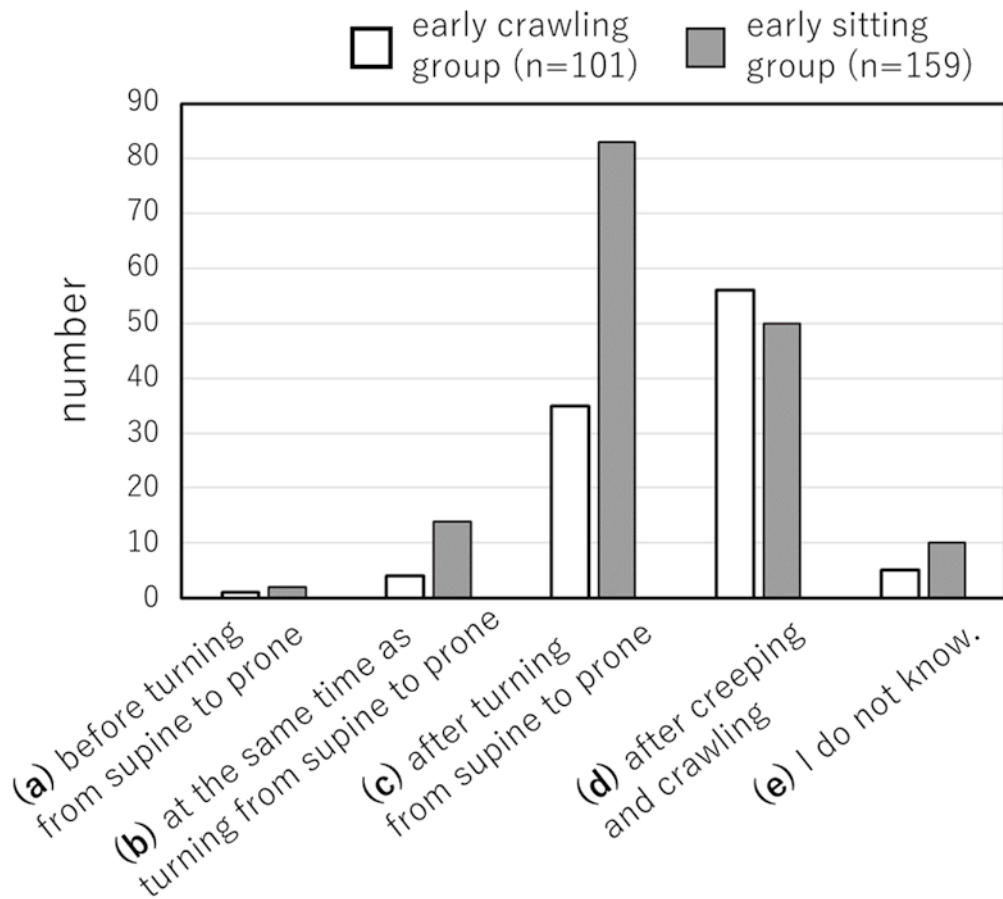


Figure 3. Parents' understanding of when infants acquire a sitting posture.

ordinary sequence and 159 infants (61.2%) showed reverse sequence. The total of 260 infants included 142 males and 118 females. There was no statistically significant relationship of the incidence of early sitting with the infants' sex, the employment statuses

of their parents, or living with at least one of their grandparents ($P > 0.05$) (Table 2).

The 13th question in the questionnaire collected answers from five choices on how parents understood when infants would be able to sit up

Table 2. Sex and employment status of parents of infants.

| | Total (<i>n</i> = 260) | Early crawling group (<i>n</i> = 101; 38.8%) | Early sitting group (<i>n</i> = 159; 61.2%) |
|-------------------------------------------------------|-------------------------|--------------------------------------------------|-------------------------------------------------|
| Sex of subjects (infants) | | | |
| Male | 142 | 56 (39.4%) | 86 (60.6%) |
| Female | 118 | 45 (38.1%) | 73 (61.9%) |
| Employment status of mothers (no response: 1) | | | |
| Full-time | 160 | 64 (40.0%) | 96 (60.0%) |
| Part-time | 75 | 30 (40.0%) | 45 (60.0%) |
| Independent | 11 | 4 (36.4%) | 7 (63.6%) |
| Housewife | 11 | 2 (18.2%) | 9 (81.8%) |
| Others | 2 | 0 (0%) | 2 (100%) |
| Employment status of fathers (no response: 12) | | | |
| Full-time | 218 | 86 (39.4%) | 132 (60.6%) |
| Part-time | 8 | 5 (62.5%) | 3 (37.5%) |
| Independent | 19 | 6 (31.6%) | 13 (68.4%) |
| House-husband | 0 | 0 | 0 |
| Others | 3 | 1 (33.3%) | 2 (66.7%) |
| Living with grandparents (no response: 1) | | | |
| Yes (one or more) | 60 | 26 (43.3%) | 34 (56.7%) |
| No | 199 | 74 (37.2%) | 125 (62.8%) |

The percentages (%) of infants of the early crawling and early sitting groups among those with each attribute (sex, employment status of parents) are shown in parentheses.

unsupported (Fig. 3). The most common response was “(infants generally acquire a sitting posture) after turning from supine to prone”, with 118 of 260 parents answering this question. In this category, 83 infants (70.3%) were in the early sitting group that showed the reverse sequence of acquiring the creeping/crawling and sitting postures, and 35 (29.7%) were in the early sitting group that showed the ordinary sequence. Of 159 cases in the early sitting group, only 31.4% of the parents (50 cases) correctly answered the order of motor ability acquisition of infants in the general milestone sequence. On the other hand, of 101 cases in the early crawling group, 55.4% of the parents (56 cases) had a clear understanding of when the infant would be able to sit without support. The infants of the early sitting group were significantly less with parents who answered “(we/I think babies become able to sit up by him/herself) after creeping and

crawling” and were significantly enriched with parents who answered “(babies become able to sit) after turning from supine to prone” (Table 3). Further, 52.2% of the early sitting group assumed that once an infant turned from supine to prone, the infant should be able to sit up already. Moreover, 10 out of 159 parents of the early sitting group indicated they did not know when their infants should sit up. The analysis determined whether this parental understanding affected infant’s patterns of creeping-sitting milestones. The results showed that ambiguous parental knowledge led to reversal of the creeping-sitting milestones.

Discussion

The sitting posture in the motor development needs to be observed from both points of view of movement and posture maintenance for infants. The

first point is the ability of infants to get a sitting posture by spontaneous movements such as creeping without support, while changing positions on their own from a lying posture. The other point is to be able to maintain the sitting posture prepared by adults' help. In both cases, infants acquire the sitting

development stage. During the creeping stage, they look for horizontally approachable objects while lying on their back, and subsequently reach for vertically placed targets, such as books on a shelf, using their hands and knees during the crawling stage. In this way, the infant is always interested and will use

Table 3. Relationship between the acquisition order of crawling and sitting-up unsupported in infants and their parents' understanding of the timing of the children's acquisition of sitting posture.

| Category | a | b | c | d | e | Total |
|--------------------------------------------------------|-------|-------|-------|---------|-------|-------|
| Number of early crawling group | 1 | 4 | 35 | 56 | 5 | 101 |
| Number of early sitting group | 2 | 14 | 83 | 50 | 10 | 159 |
| Total | 3 | 18 | 118 | 106 | 15 | 260 |
| Percentage of early sitting group within each category | 66.7% | 77.8% | 70.3% | 47.2% | 66.7% | 61.2% |
| Enrichment factor | 1.09 | 1.27 | 1.15 | 0.77 | 1.09 | |
| <i>P</i> value | 1.00 | 0.34 | 0.01* | <0.001* | 0.99 | |

The 260 children were defined into early crawling group and early sitting group by their parents' answer to the 7th question. The children of both groups were also assigned to one of five categories (a–e) by their parents' answer to the 13th question. The categories were defined by the participants' answer that infants generally acquire their sitting posture (a) before turning from supine to prone, (b) at the same time as turning from supine to prone, (c) after turning from supine to prone, (d) after creeping and crawling, and (e) I do not know. Enrichment factors were defined to show the difference in ratio of the early sitting group in each category as $(nfn)/(Nf/N)$, where nf is the number of infants of the early sitting group within the category; n is the total number of infants within that same category; Nf is the total number of infants of the early sitting group in any categories; and N is 260, which is the total number of infants. Statistical analysis was done using Fisher's exact test with hypergeometric distribution followed by the Bonferroni correction (* $P < 0.05$).

posture by repeating the process of continuously controlling and coordinating their movements from the lying posture. Therefore, there are several dynamic developmental stages in the process of acquiring the sitting posture. In this process, it is necessary to prepare a childcare environment that does not restrict spontaneous movements and enhances the infants' own motivation for free movement, as described by Pikler. Pikler's diagram (Fig. 1) shows how infants acquire the milestones in their motor development (Pikler, 1972), especially in relation to supported sitting (Fig. 4).

According to Piaget (1966), infants gradually become constant object-seekers, searching and reaching for new objects during the motor

their sensorimotor functions to reach for new objects placed in high positions in the environment. During the stage when standing is not supported by the spine, the temporary solution of the infants is to acquire a sitting posture for reaching higher objects.

In this study, the acquisition process of motor development was investigated by focusing on the postural change from crawling to sitting in infants. Our questionnaire-based survey revealed that 61.2% of infants acquired unsupported sitting before they started creeping or hands-and-knees crawling, indicated that the order of acquisition of developmental milestones is reversed. Therefore, we investigated the potential cause of the reverse order. We hypothesized that parental awareness might have

influenced on the acquisition of sitting posture of infants. Previous studies have suggested that intentions and interventions of parents to their infants affect their gait development (Shiraga, 2008). Intentions and interventions are also thought to affect the acquisition of sitting posture, which can be achieved by holding the infants' posture by an adult (Fig. 4). The acquisition of sitting posture is written as an indicator, like a milestone, of the motor development in the governmental mother and child health handbook in Japan. However, the developmental process of an infant is not something that can be taught or trained by parents as an indicator, but is in itself a continuum that infants have. Pediatricians generally divide infants' sitting-up into supported and unsupported positions. When an infant sits up spontaneously from a lying position, he/she first turns on his/her side and then pushes him/herself from a half-prone lying to a prone position to achieve a sitting position. Therefore, the infant does not acquire spontaneously the sitting posture directly from their lying position.

The process of dynamic acquisition of the sitting posture was reviewed by Pikler in the 1970s, but it has not been fully investigated for infants for the past 40 years. In this context, the Japanese governmental mother-child handbook (Ministry of Health, Labour and Welfare, 2020), asks parents the following questions.

Record of motor development (at about 6-7 months of age)

- Does he/she turn over? : Yes / No
- Does he/she sit up? (Around 7 months of age)
: Yes / No

The date(s) of sitting-up unsupported
(day/month/year)



Figure 4. A picture of an infant supported at a sitting position.

During our current investigation, we observed that some parents has misunderstood that infants generally learn to sit up when they start to turn over on their own, and have their infants practice sitting up supported immediately after turning over. The supports of adults by holding infants at the sitting posture at this stage of development may deprive the infant of the opportunity to stabilize the prone posture by themselves. Therefore, external support in the first anti-gravity posture, immediately after the infant has started to turn from supine to prone position by themselves, should be questioned. In addition, the process of the infant turning from just lying down to creeping and making spontaneous movements while creeping should be respected. The focus on parents' awareness in this study is a potential relationship with the infants' acquisition of the sitting posture on their own without help of adults. The potential effect of this crawling-sitting acquisition process on their subsequent growth should be investigated with various perspectives including emotional and social aspects in future studies. Furthermore, preparations for the next study are underway with reduced number of questions to make it easier for participants to answer and to analyze the data with a high response rate.

Previous studies in Canada have suggested that the survey should be done by distinguishing between supported (with external support) and unsupported sitting postures to better understand the developmental trajectory. However, that study did not point out any problems similar to those in the mother-child handbook in Japan in surveys commonly conducted by doctors in Canada to diagnose abnormal reflexes and decreased muscle tone in early infancy. The results of our present study suggest that items in the Japanese mother-child handbook (Ministry of Health, Labour and Welfare, 2020) such as the diagnostic criteria for checking infant development tend to make parents try to make their children do exactly what is written in the handbook. Therefore, it is recommended that the relevant mother-child handbook be revised to appropriately represent motor developmental milestones with their clear definitions.

At nursery schools and kindergartens in Japan, the spontaneous activities of infants themselves are

beginning to be more respected. There is need for an environment where babies can move their bodies, get their senses, and experience the joy of physical activity in their daily play. The Childcare Guidelines for Nursery Schools in Japan (Ministry of Health, Labour and Welfare 2018) declares the importance of preparing environment where children can move freely enough to gain rich experience in mental and physical interactions through enjoying activities such as crawling, standing, and walking with playing. It is also important to prepare environment that matches the individual differences and interests of children. To monitor the developmental process of infants, it is necessary to carefully observe and support the dynamic process of motor development, regardless of whether the infant has acquired the sitting posture or not.

Conclusion

In the present study, we investigated the process of acquisition of unsupported sitting posture in motor development of 260 infants in Japan. The acquisition order of creeping/crawling and sitting postures was focused on and compared with the theory proposed by Pikler (1972) that infants develop in the following order: creeping, hands-and-knees crawling, and sitting-up unsupported. The results revealed that more than half (61.2%) of the infants acquired motor abilities in the reverse order, unsupported sitting-up earlier than creeping or hands-and-knees crawling. The potential causes of the reverse order are cultural reasons and parents' misinterpretation of the definition regarding milestone postures advised by the governmental mother-child handbook in Japan. We propose that the handbook be revised to clarify appropriate expressions and definitions regarding milestones in motor development. This study also suggests the need of further investigation of the effects of environmental factors, such as the use of infant equipment, on the motor development as it relates to the spontaneous movement of infants.

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