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Original Research

Developmental process of children's movement from a physiotherapeutic point of view

—— The necessity of physiotherapists of observing baby's and infants' behavior at medical check-ups ——

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Abstract

Birthrates have been declining and living environments have changed over time. This may have affected children's motor development and led to injuries that could have been prevented. It is well understood that it is essential for children in early childhood to play, but the present era has witnessed a change in their playing behavior. They mostly play indoors because their playing time has become shorter and their toys have changed to electronic devices. Too much time indoors has led to concern about declined activeness or fragility of children when they enter grade school or puberty.

This paper discusses children's developmental process from a physiotherapeutic viewpoint focusing on their achieving many levels of motion in order, such as holding their head, rolling over, sitting up, crawling, standing, and walking, and identifies how fine and gross movements are linked to each other in progressive physical development. The objective of children's check-ups is to identify any developmental issues at early stages and provide support. However, developmental delay could be missed if the check-ups only rely on the medical interview sheet because use of the sheet might vary depending on the criteria applied by assessors, and parents may fill in the sheet according to their standard. Therefore, intervention by physiotherapists, who can observe the children's behavior objectively, may be required.

This study identifies the significance of physiotherapeutic observation of children's behavior at check-ups and proposes a new approach for the check-ups to identity developmental disorders for early intervention. Moreover, the study will help parents and other adults understand how they should take care of children and how they can prevent developmental disorders.

Key words: check-up for babies and infants, change in playing behavior, physiotherapy, physical activity, developmental process

Ⅰ. Introduction

Basic physical fitness of children has shown an annual decline. At nurseries and kindergartens, more injuries have been seen related to exercise equipment. Children in early elementary grades have more injuries that could have been easily prevented, such as fractures after falling onto a flat surface. It is a well-known fact that children naturally acquire the ability to avoid such injuries while they play (Suga, 2006) .

However, it is also known that present-day children lack the experience of playing outdoors. Now "playing outdoors" means playing at nursery, and playing itself has shifted from taking place outdoors to indoors. Now, more and more

children are unable to play outdoors on their own. It is a concern that they cannot develop motor functions and muscles that should be promoted by playing. This study discusses from a physiotherapeutic point of view why children's motor development has slowed down and what motor development process they should go through from babies and infants to six-year-old children. We consider that the changes in the developmental environment of babies and infants has contributed to the reduced physical abilities, not to mention the lack of playing outdoors while at grade school. Skills acquired in early childhood are known to affect development in the future. Cognition, body, movement, and social ability are linked to each other when they develop (Tomimoto, 2017). This development is largely affected by actual "experience." How much a child can "experience" depends on their motor development. The acquisition of physical abilities through playing affects the development of other regions.

An overview of previous studies on check-ups for babies and infants identified many cases of linguistic delay and disorders (Suyama et al., 1985 ; Hiraoka, 2011). Linguistic development was suggested to be closely linked to large movement, fine movement, social ability, search behavior, independence in daily activities, and problematic behavior (Suyama et al., 1985). The same authors reported that social ability was significantly affected and other problems concerning motor ability, such as search behavior, daily habits, uncontrollable habits, or being restless also followed as linguistic delay was repeatedly detected at check-ups at the ages of one and a half years and three years. Also, it was suggested that the check-ups at one and a half years was very important to identity developmental disorders in a comparison study between check-ups at one and a half years and three years. To identify developmental disorders, the check-ups at one and a half years is important, but it is hard to identify problems at early ages due to individual variation. It was suggested that the present system of check-ups should be reviewed (Hiraoka, 2011 ; Murata et al., 2010 ; Kohori, 2014 ; Honda, 2014).

Children develop orderly from the head to neck (being able to hold their head), and then from the upper limbs, and trunk, to lower limbs (being able to grab things, roll over using hands, sit up, crawl, stand, and walk). Roll-over requires the work of the shoulders, elbow joints, and hands. It also means that children are interested in objects near to them and try to grab them. Grabbing and rolling over are connected. With their physical movement extended, their visual field becomes wider and their cognition and emotions develop further. This way, emotional and physical fields are clearly interactive in development. For instance, crawling facilitates not only locomotion but also cognitive and emotional development. Additionally, children who have expanded their territory by crawling will crawl even more because of their further interest in the surroundings. As a result, physical and cognitive fields, or crawling and taking an interest, develop bilaterally. Children whose physical function is handicapped in the case of CP, for example, do not show this course of development (Sato, 1998).

Crawling, seen from a physiotherapeutic point of view, is a coordinated movement of the upper and lower limbs and body trunk. It is a full-body motion that simultaneously requires a holding ability and weight supporting ability involving the limbs and body trunk. However, we believe that this transfer activity of crawling is currently less emphasized in the process of children's development. When mothers at the children's check-ups mention that their babies do not crawl, the doctors simply answer that it is alright. This is because they do not wish to make the mothers worry about child-rearing, but the result is that Mothers view crawling as unimportant.

Crawling on the hands and knees can be a defense against injuries. It also satisfies children's desire and helps them understand steps necessary for trouble shooting. There may be developmental problems before "crawling" is mastered. Each behavior in the course of children's development leads to another development. This mechanism must be clarified from a physiotherapeutic viewpoint.

Ⅱ. Present situation of children's check-ups and development quotient (DQ) of DENVER Ⅱ

1. Present situation of children's check-ups and their development

The objective of children's check-ups (check-ups) is to assess their healthy growth and give counseling to families (mothers) about the children's health. According to the Maternal and Child Health Act, check-ups are conducted for children aged three months, a year and a half, and three years to confirm the children's normal development for respective ages. The check-ups involve a medical interview sheet given to mothers (those who rear the child) prepared by respective municipal governments and doctor's

examination. If the interview sheet responses necessitate further tests, simple examination is additionally conducted. The consultation rates of check-ups for a year and a half and three years respectively are over 90% according to the national survey (Nakano et al., 2003). The health survey of children in 2010 (committee members, 2010) indicated that more time was spent watching TV or playing video game than playing in other ways compared with the results from ten years ago. A total of 26% of the 1.5 to 2-year-olds watch TV for two to three hours, 30% of the three-year-olds, and 32% of the four-year-olds. These children should play for most of their time and their physical and social abilities will develop rapidly. If they are sedentary for a long time and stay indoors, their mental, social, and physical development will be at risk.

A study on screening suggested that supporting children is just as important as supporting parents and families (Hada et al., 2005). Support should be provided for not only children in trouble but also parents whose children watch TV for too long. In particular, fathers who are expected to play with children should support child-rearing. Many studies have been conducted on how fathers can help to reduce mothers' child-rearing anxiety. It was suggested that fathers' involvement with playing with the children was significantly correlated with the social and physical development of children in early childhood and that it would facilitate such development (Nabeshima et al., 2015).

It was reported that children who were advised about abnormity at the 1.5-year-old check-ups showed normal growth at the three-year-olds check-ups, and the importance of the 1.5-year-olds check-ups was emphasized (Hongo, 2006). The study also identified the relation between four-month-olds at the three-month check-ups and 1.5-year-olds at the 1.5-year-olds check-ups. This suggested that identification and approach implementation in early stages were critical. In a different study on check items listed on the interview sheet to determine support, abnormity was identified at the three-year-olds check-ups after some items were missed at the 1.5-year-olds check-ups ; the children who had been supported since the discovery of abnormity at the age of a year and a half grew normally when examined at three years of age (Koide and Nekoda, 2007). This suggests the presence of items common to the check-ups at 1.5 and three years olds.

Studies on check-ups of 1.5-year-olds (Simizu, 1998 ; Itami et al., 2017) or three-year-olds (Simizu, 1998 ; Hongo, 2006) mainly focused on check items on the medical interview sheet. There were few studies on the observation and verification of the children's behavior associated with their moving region. Children who were found to need support showed developmental delay, with significant differences in the following items on the medical interview sheet : try to take off clothes ; hold a cup ; eat with a spoon and fork ; and show peculiar behavior (Itami et al., 2017).

In the analysis of the medical interview sheets 1.5-year-olds (Hongo, 2006), a significant difference was identified between the group not followed up (children who didn't require support) and follow-up group (children who were found to require support) in the following moving region items : go upstairs when lead by hand ; scribble with a pencil ; and pile two blocks. Significant differences were also identified in three items in the linguistic region. These results show the relation between fine movement, large movement, and the linguistic region. Moreover, a study on children with developmental disability identified at five years of age suggested that some items such as "peculiar behavior" or "unable to understand directions" were hard to detect as developmental problems at the 1.5-year-olds and three-year-olds check-ups, and that a common understanding to these items among those involved with child-rearing was difficult to achieve (Tamaru and Koeda, 2010). These studies support the connection between the 1.5-year-olds and the three-year-olds check-ups.

A significant correlation was identified between all check items of the three-month-olds and three-year-olds medical interview sheets (Koide and Nekoda, 2007). The items could be divided into children (their development in four regions), family and child-rearing environment (family relationship, supporters, finance, etc.), and Mothers (child-rearing attitudes, thoughts on child-rearing). This also suggests that maternal baby-rearing attitudes affect the infants. The study on the developmental situation at the three-year-olds check-ups compared the results from 1994, 1997, and 2003 (Yamaguchi, 2002). A significant decrease was reported in self-support in daily activities and moving region. It was emphasized that some children didn't use chopsticks well because their care providers didn't show how to use them. Delays in moving region or speech are often connected to insufficient time for the mothers to play with children or their inability to interact with children. A mother of a child who showed linguistic delay

asked while being counseled if there was any other play activity except piling blocks. Like her case, some mothers are not aware that interaction between mothers and children itself is an act of playing (Hasegawa, 2013). It is considered that the mother just observed nearby while the child was playing with blocks. This most likely didn't involve exchanging speech and must have limited the child's movement. This could lead to secondary developmental disorder.

Some districts in Japan employ efforts for the earlier detection of autism at the 1.5-year-olds check-ups. Early detections were already reported as some of the earliest cases in the world (Honda, 2014). Some children who were not diagnosed with autism showed the so-called "First Grader Problem (Yamaguchi, 2002). They showed potential problems such as paying no attention or ignoring instructions. Class management became difficult and some schools had to introduce nursery teachers. Developmental disorders or behavioral problems of these children might not have been identified at the present 1.5-year-olds and three-year-olds check-ups, and so children might have entered elementary school without being understood by adults surrounding them and may have just been regarded as troublesome children. It is crucial to establish a system to ensure that these children are not missed at the check-ups for 1.5-year-olds and three-year-olds.

2. DQ of DENVER Ⅱ

The Denver Development Screening Test (DDST) was published in 1967 for health and medical workers to be able to detect children's developmental delays at early stages, identify potential developmental problems, and cope with the situations (Frankenburg WK and Dodds JB ; 1967). DENVER Ⅱ was prepared in 2003 by upgrading the measurement in linguistic development or moving region (Frankenburg WK et al., 1987 ; Frankenburg WK et al., 1992 ; Glascoe FP et al., 1992).

DENVER Ⅱ enables the early detection of children's developmental problems and specifies the area of problems by screening. The Growth Committee of the Japanese Society of Child Health led efforts to standardize DENVER Ⅱ in Japan (Simizu B, 2004 ; 2006). Children with mild developmental disorders are difficult to differentiate from normal children. Adults feel that something is wrong but children appear to be without any developmental problems. It is often not until they enter elementary school that parents and teachers notice the underdevelopment. It is critical to detect and cope with developmental problems as soon as possible. The standardized version was developed from the intuitive DENVER Ⅱ into one allowing objective assessment. It's a useful screening tool for early detection and intervention.

DENVER Ⅱ can assess children's various abilities in four categories (Frankenburg WK et al., 1992).

1) Individual - society : cooperation with others, self-support.
2) Fine movement - application : coordination of eyes and hands, handling small objects, trouble shooting.
3) Language : listening, understanding, and using.
4) Large movement : full-body muscular movement like sitting, walking, and jumping.

The record sheets are made for each age from one to six and the measurements are entered into four categories. The assessors can ask questions to the mothers during the screening test. That way, children's development level is easy to judge. Simple movements in the moving region can be demonstrated by the children. This is not possible for ordinary medical interview sheets which only contain mothers' answers.

Analysis of the medical interview sheets and simple developmental tests at the 1.5-year-olds and three-year-olds check-ups revealed the following (Hongo, 2006) : 94.5% of the 1.5-year-olds could go up stairs if by hand ; 75.8% could not. A significant difference was percentage ($p<0.01$) in the above. According to the answers provided by mothers at the three-year-old check-ups, 99.7% of the children could jump from a height of 20 to 30 cm ; 93.9% could not. Similarly, 95.5% could stand on one leg ; 84.8% could not.

Again, a significant difference was identified ($p<0.05$).

When a delay is detected, there is no counseling for mothers at the check-ups. Physiotherapists do not intervene until a delay is identified at a check-ups (Sugiura et al., 2016). However, at some hospitals, physiotherapists or occupational therapists are involved in children's check-ups (Sasaki, 2010).

DENVER Ⅱ was prepared for the early detection of and intervention for delay. However, it tends to be adopted after children have been told of their problems at the 1.5-year-olds or three-year-olds check-ups. There are three main characters is tics of DENVER Ⅱ : it is easy to implement ; its criteria are easy to understand ; its

criteria are fair and objective. However, observers of children's behavior will have different methods of judgement. The Japanese Society of Child Health recommends using DENVER Ⅱ's developmental test at children's check-ups. However, it requires expertise and experience. Currently, developmental disorders are often missed at the 1.5-year-olds check-ups (Tanak, 2013).

DENVER Ⅱ 's developmental assessment of fine movement and moving region still relies on mothers' reports and it cannot identify the specific problem or its severity. Therefore, observation and questions from physiotherapists' point of view are required to specifically discover children's developmental problems at early stages. It has to be considered how child-rearers can help resolve children's developmental disorders after diagnosis. DENVER Ⅱ is a tool to assess development. It can be an index of development at different months of age. However, even nurses and doctors who care for children do not have enough knowledge and skills for the required developmental support. The necessity of a physiotherapeutic approach has yet to be adequately understood.

The problem of child abuse is becoming worse every year. Child maltreatment is another serious issue : children are rejected due to parents' priorities ; the parents negatively effect on the children by not showing any interest in them or force them to be excessively independent (Nakano et al., 2003). Such maltreatment is likely to lead to additional problems in cases of children diagnosed with developmental disorders or disabilities at the 1.5-year-olds or three-year-olds check-ups. Also, individual variation is often considered to affect the development of fine and large movements. Mothers tend to find it hard to accept or deal with the problem when it is presented. It is important to have a clear physiotherapeutic point of view and understand the sequence of development where a children's activity is connected to the next level of growth. This is the way to prevent developmental disorders and facilitate healthy development.

3. Children's fine and large movements and physiotherapeutic viewpoints (Maturity principles of motor development)

Motor abilities develop progressively with four principles. They develop : (1) from cephalic to caudal portions ; (2) from the center to periphery ; (3) from generalization to differentiation ; (4) from large movements to skilled motor activities (Winnick J, 1992).

Principle 1 defines the progressive development from the cephalic to caudal portions. Eye movement is followed by upper limb motion and then that of the lower limbs. This means that the development of the upper parts of the body (head and neck) precede that of the lower parts (limbs and body trunk). Principle 2 defines the development from the center to periphery (from inside to outside). This means that the body core develops before the periphery, with this core development further promoting peripheral development. Principle 3 defines the development from generalization to differentiation. It means that most movements in the baby and infant period start from full-body movements and then differentiate into movements of distal portions of the extremities. Principle 4 defines the development from large movements to skilled motor activities. This means that large, awkward motions gradually develop into fine, skilled targeted motions. Through this, children grow one step at a time. This progressive development of voluntary movement is associated with the following three functions : sensory organ, cerebral nerve, and muscles & bones. When the three functions develop well and are able to coordinate, then targeted motions can be achieved in order. When this orderly progress is impaired, various disturbances of coordination and movement are likely to occur.

Below is a summary of the development of large and fine movements of children from a physiotherapeutic point of view (Table 1).

Ⅲ. Development & support from a physiotherapeutic viewpoint

1. Development is adapting to gravity

Newborns are subject to gravity. At about a month old, they begin to move their head up and down, back and forth, and left and right. They begin to realize their basic center of gravity in this way. Next, they shift the gravity center little by little and learn how to move their body within a specific range. Then, they can hold their neck, roll over, sit up, and crawl. They repeat such motions many times, shift their gravity centers, make their base of support smaller, and eventually stand and walk. This is the developmental path of babies and infants (Seki, 1994). However, it has been recognized that they can already turn their head, move their limbs, and suck their fingers in utero. These motions may be re-learning what they did in utero as a result of being exposed to gravity immediately after birth. In other words,

Table 1 Fine & large movements at age in months and physiotherapeutic viewpoints. (Piek JP, 2006 ; Hosoda, 2016)

Age in months	Fine or large movement	Physiotherapeutic viewpoint ; Significant development
1	lift head keep sight away from median line until 45° symmetrical motion clench hands	〈supine position〉 Because of the bending posture, the center of gravity is shifted to the head, and the head rotates. When such a recoil phenomenon is seen, the proprioceptive organ input increases and the activity of the trunk improves. When body trunk becomes stable, hands begin to move easily and reach the mouth. This causes a rooting reflex and stimulates the head to turn. 〈abdominal position〉 If the position of the center of gravity is in the face, shoulders, and chest because of the bending posture, breathing motion induces weight shifting back and forth. When the hip joint comes out due to the kicking motion of the lower limbs, the position of the center of gravity of the face or chest replaces that of the abdomen. Therefore, the body trunk muscles become active, shoulder girdle muscles become stable, and the head can be lifted easily. The center of gravity position is transferred to one side of the shoulder band or upper limb・trunk by the rotation of the head, and it becomes a preparatory stage to start supporting the weight only by the muscles.
2	keep sight away from median line beyond 45° lift head by 45°	
3	keep sight away from median line until 180° lift head by 90° (smile when lulled) gaze at own hands hold a rattle	
4	shake a rattle put both hands together hold up head sit with support	Activities expand from holding the head on the median line or putting both hands together to execute motions away from the median line. 〈supine position〉 Extremities stretch more and the gravity center shifts from the occipital protuberance to shoulder girdle muscle and thoracolumbar spine. Hands try to reach out more. With this motion, the body trunk easily turns. Rolling over is stimulated. Muscles of the lower body trunk become active. 〈abdominal position〉 The gravity center shifts from the chest to abdomen and pelvis. The airplane posture with stretched body trunk and limbs is seen and upper limb support improves to stabilize the body trunk. 〈seated posture〉 Both hands are on the floor but the posture is unstable. The child tries to broaden the chest and raise the body trunk when interested in something. When the chest is broadened, the pelvis can be raised easily. Pectoral major muscle is important to lift hands from the floor and it works well when the airplane posture is adopted. With a high level of wakefulness, the brainstem is activated and the posture is easy to control.
5	turn to the direction of the voice reaching for things grab a toy roll-over	
6	look and take things : coordination of eyes and hands hold with a rake hold blocks with both hands sit up	
7	hold blocks pass blocks from one hand to the other sit up for five seconds or more	
8	use thumb to pick up objects hit blocks to make a sound keep standing by holding onto something sit independently crawl	〈seated posture〉 Seated posture becomes more stable. Abduction or external rotation and internal rotation of hip joint enlarges the support surface and the weight can be shifted sideways easily. The pelvis is easily raised and reach behavior is possible even when the body trunk raised against gravity. Posture change from seated to lying and from seated to crawling becomes smooth. At 7 months, the scapular is retraction, so the reachable areas are smaller.
9	use thumb to pick up objects hit blocks to make a sound pull to stand up stand independently	
10	put blocks in a cup crawl actively stand independently walk independently	〈standing〉 Lower limbs are abduction to achieve a larger support surface, which makes the pelvis tilt forward. Then the scapular is introverted and it is difficult to raise and stabilize the body trunk against gravity. By tilting the pelvis backward and putting weight on the heels, the body trunk stretches and ankle joints function better. Then, it becomes easy to shift the weight sideways. When the body trunk is stabilized, the upper limbs are not used for transfer. Hands do not have to support the body anymore ; instead information can be obtained through touching objects with hands. The role of hand changes from support to operation. 〈walking〉 Since the center of gravity moves forward when walking, the center of gravity returns to the back by raising the upper limbs. When the hands are lowered, walking is more controlled and balanced. Posture is maintained by obtaining information from the soles. Sensation of the soles is important. Support by soles and mobility of the ankle joints are critical.
one year	scribble thumbs can be opposable pick up small objects with a thumb and a finger pile up two blocks walk skillfully	
One & a half years	remove raisins from a jar pile up 2 to 4 blocks walk without falling kick a ball	Fine movement follows large movement. With the fingers it will be possible to grip from the inside to the outside. Maturity of cortex motor area of the brain is seen with the development of the fingertip. The child begins to copy adults' behavior and becomes more interested in the surroundings.
2 years	pile up 6 to 8 blocks throw a ball walk backward run go up stairs	Playing becomes varied. Imagination and creativity are exerted. Communication with others is enjoyed. This way, development of mind and body advances as well as coordination of the whole body.

Table 1 Fine & large movements at age in months and physiotherapeutic viewpoints. (Piek JP, 2006 ; Hosoda, 2016)

Age in months	Fine or large movement	Physiotherapeutic viewpoint ; Significant development
3 years	copy a vertical line copy a circle move thumbs only jump pedal a tricycle	Basic motions are mastered and further improve. The child becomes skillful at using tools and apparatus nearby. Overall coordination and balance improve. A total of 80 % of brain is development believed to be complete at the ages of three to five. Various experiences help ; "playing" is essential. It nurtures not only physical functions but also thinking ability and concentration power.
4 years	draw a circle copy a cross copy a square stand on one leg (4 sec) hop on one leg	
5 years	draw a cross and square draw part of a person stand on one leg (6 sec) do a forward roll	
6 years	draw a square diagonally skip play on a climbing frame jump down	The child can combine motions such as running and bouncing a ball at the same time. The child can absorb much more and keep on developing. During this period the hippocampus and the brain cortex develop.

the development of babies and infants is adaption to gravity. In this way, gravity is a big hurdle to overcome as it works to impair movement. Children repeat the motions progressively, learn to resist gravity, and re-establish new patterns of movement. The beginning of the adaption to gravity involves primitive reflexes.

The primitive reflexes appear from the fetal stage and disappear in the course of development (Dimitrios, 2004). For example, babies and infants grip an object when it contacts the palm. This primitive reflexes is caused unconsciously by a stimulus. The reflex center of babies and infants lies in the spinal cord and brainstem, but conscious movement (voluntary motions) predominates with the development of the midbrain and cerebral neocortex and the primitive reflexes disappear. For example, children can consciously move their fingers when the hand grasp reflex disappears and they are able to walk when the foot grasp reflex disappears. The role of the primitive reflexes is to help children regain their physical movements shown in the womb in order to cope with gravity. As motions caused by primitive reflexes are repeated, the central nerve system matures and muscles strengthen. As a result, movements that were once reflexes can be performed voluntarily.

When the motor development of babies and infants is considered, it is important to understand voluntary motions induced by primitive reflexes, confirm that these voluntary motions are properly conducted, and ensure the appropriate developmental conditions.

The next section describes when typical primitive reflexes appear and disappear and how voluntary motions are induced.

2. From primitive reflexes to voluntary motions (Table 2)

Primitive reflexes are commonly seen until several months after birth (Saito, 2012). These are for the newborns to survive the period immediately after birth. They are the base for their conscious and voluntary movements later on. Normally, primitive reflexes become integrated and disappear. If they remain for some reason, they may affect normal development (Kibe, 2002 ; Maekawa et al., 2007). Below are the typical primitive reflexes and when they appear and disappear, as well as voluntary motions (Haitani, 2016).

1) Asymmetrical tonic neck reflex (ATNR)

This appears in utero and disappears around six months after birth.

When the head of a baby in a supine position is made to turn sideways, upper and lower extremities on the same side that the head is turned stretch and those on the other side curl. This reflex helps them develop a sense of distance and coordination between hands and eyes through the cooperation of the upper limbs (tactile sense) and head (visual sense). This is believed to be the base of watching and touching movement. The reflex is asymmetrical ; therefore, it also helps the children recognize their central axis.

2) Tonic labyrinthine reflex (TLR)

This appears in utero and disappears around three years after birth.

Upper and lower limbs of the baby curl when they are set in an abdominal position ; in a supine position, both limbs stretch and their back curls.

Table 2 Nerve level of primitive reflexes : Appearance & disappearance (Saito, 2012 ; Kibe, 2002 ; Haitani, 2016)

Maturity level of central nerve	Reflex	Age at appearance	Age at disappearance (motion)
Spinal cord	Grasp reflex	palmar grasp reflex : at birth	4 months (grasp)
		plantar grasp reflex : at birth	10 to 12 months (walk)
	Galant reflex	at birth	before 4 to 5 months (hold head)
	Rooting reflex	at birth	before 4 to 5 months (hold head)
Brainstem	Moro reflex	at birth	4 months (hold head)
	Asymmetrical tonic neck reflex (ATNR)	in utero	6 months
	Tonic labyrinthine Reflex (TLR)	in utero	around 3 years
	Symmetrical tonic neck reflex (STNR)	4 to 6 months	12 months (crawl)
Midbrain	Righting reflex	6 months	5 years
	Landau reflex	1st layer : at birth	6 weeks
		2nd layer : 7 weeks	3 to 4 months
		3rd layer :	6 months to 2 years
Brain cortex	Parachute reflex	6 months	lifelong
	Hopping reflex	1 to 1.5 years	lifelong
	Stepping reflex	1 to 1.5 years	lifelong

This helps to nurture a sense of balance while moving. The abdominal reflex disappears three to four months after birth. The supine reflex remains until around three years old.

3) Moro reflex

This appears in newborns and disappears around four months after birth.

When they sense danger, they unconsciously spread out the arms and seemingly hug something. This is a defense reaction of hugging when they are surprised or fearful. Once this reflex disappears, the neck is ready to develop and the babies can hold their head.

4) Grasp reflex

This appears in newborns and disappears around four months after birth.

This is divided into two types of reflexes : the palmar grasp reflex and plantar grasp reflex. When touched on the palm or sole, they curl their fingers or toes as it to grasp something. The palmar grasp reflex disappears around four months after birth when voluntary grasp motion is acquired. The plantar grasp reflex disappears at around one year of age when they begin to walk.

5) Rooting reflex

This appears in newborns and disappears four to six months after birth.

When they feel a nipple or finger around their mouth, they turn the face toward it and make sucking motions with the mouth. This induces voluntary movement of the neck region and it disappears when they can hold their head.

6) Galant reflex

This appears in utero and disappears three to nine months after birth.

When the babies are held in ventral suspension with their chest supported and given a stroke along either side of the spine, they laterally flex toward the stimulated side. Muscles become tense by repeating this reflex and a sense of physical balance can be nurtured. This reflex is already present in utero. It is said that this reflex movement aids delivery when the babies go through the birth canal. They learn how to move their body trunk laterally through this reflex and also learn how to crawl.

7) Symmetrical tonic neck reflex (STNR)

This appears six months and disappears around 11 months after birth.

This might be caused by the inhibitory effect of the TLR. The babies and infants for the first time move their head against gravity in this reflex. This reflex also affects the development of visual sense and works as a preparation for crawling.

8) Parachute reflex

This appears around eight months after birth and lasts for the entire life.

This appears with the development of the midbrain and brain cortex. It is similar to the reaction you balance with your hands. When children trip and lose their balance, they can land on the hands. It is retained once learned.

Primitive reflexes are controlled by the spinal cord and brainstem and appear and disappear according to the stage of development (Haitani, 2016). When the brainstem develops to some extent, the midbrain and brain cortex, which control more skillful motions and responses, develop in turn. With this development of the brain, the children's reflexive and unconscious responses to stimuli from the outer world evolve

into motions that are based on their will and judgement. The development of voluntary movement in babies and infants is closely associated with the appearance and disappearance of primitive reflexes. Such primitive reflexes are essential for encouraging the development of children.

All the motions required in daily life or the workplace such as walking, running, throwing, and jumping are acquired by progressing from primitive reflexes developing in babies and infants. Movements acquired by infants help children engage in various sporting activities later. Therefore, if the children do not exercise enough and grow with their midbrain and brain neocortex immature, their quality of life will be markedly affected. In particular, the primitive reflexes associated with the development of the midbrain are largely related to extrapyramidal development. It affects the maturity of muscle stress and coordination abilities and balancing. Therefore, crawling and visual stimuli are critical for normal development in later stages of life (Table 2).

Ⅳ. Development principles and prevention of delayed development (Development facilitators)

The children's development principles are as follows (Joan L and Greg C, 2008) :

1. Growth and development make progress in order.
2. There are some basic directions of growth and development.
3. Growth and development are in sequence but not always at a constant speed. Development speeds vary depending on ages.
4. There are critical periods in growth and development.
5. There are variations between individuals' growth and development.

1. Developmental coordination disorder (DCD)

DCD is a type of movement disorder whereby coordinated motions such as kicking a ball or writing letters show immaturity even though muscles, nerves, vision, and hearing are normal (Helene P et al., 1995). It is one of the development disorders. Disorder is not found in one particular function of the body ; the cerebral nerve circuit, which integrates various sensory inputs and commands the movement, is believed to be impaired. This disorder is relatively common among the majority of children who show attention deficit, hyperactive disorder, or specific learning disorder. Children suffering from this disorder already show delays in motion such as crawling and walking in early childhood. At grade school, they tend to be recognized as awkward or poor at sports and their schoolwork is affected. About five to six percent of the children aged five to eleven years develop this disorder. More boys tend to develop this than girls.

The cause has not been fully elucidated but is believed to be a complication of maternal alcohol ingestion during pregnancy, immature delivery, genetic contributors, and others.

Children with DCD show a delayed ability to hold the head or crawl in their baby-and-infant period. In their case, they did not exercise enough when the primitive reflexes appeared and disappeared. As a result, their central nervous system remained immature but the body itself developed as they became older. It is suggested that physical activities in the baby-and-infant period largely affect their later motor capability.

2. Significance of crawling (development of anti-gravity muscles)

Recently, more children begin to walk without crawling sufficiently (Kato, 2016). This will be partly due to a changed life environment (such as less Japanese-style rooms and Westernized living conditions). Crawling is indispensable for normal development. Holding the head in the crawling position strengthens the erector spinae group of the neck and posterior regions, shoulder girdle muscles, and pelvis-surrounding muscles. Additionally, supporting the body trunk in the crawling position promoters a sense of balance using the extremities. Recently, more children trip and fall carelessly, causing injuries such as fractures. This may be partly because they didn't crawl enough when they were babies and infants (Kato, 2016). Moreover, children who do not crawl sufficiently will stand or walk with support soon after they are able to sit up. Naturally, many of them begin to walk without support earlier than is typical. It is suggested that they may have physically grown with disintegration of primitive reflexes at the brainstem level and an immature righting reflex at the midbrain level.

It was reported that muscles of the back, which are supposed to develop naturally while growing up, were not strong enough because of the reduced experience of actively playing outside in early childhood (Ikuta, 2004). Immaturity of the erector spinae group caused by insufficient

crawling in early childhood was considered to be associated. The muscles of the back are essential for principal activities like standing, walking, running, and jumping. At the same time, their roles are extremely important for humans who live under the force of gravity. Therefore, immature muscles of the back leads to overall sluggish physical activities and a frail body.

V. Early detection of & intervention for children's developmental disorders

Involvement of physiotherapists in check-ups of babies and infants

The check-ups for babies and infants play an important role in the early detection of children with developmental disorders. Articles 12 and 13 of the Maternal and Child Protection Act mandate that physical check-ups should be provided for children aged one year and a half and three years, and that check-ups should be conducted of expectant mothers, babies, and infants as necessary. Municipalities are in charge of conducting these check-ups and items for check-ups are defined in Article 2 of the Maternal and Child Health Act Enforcement Regulations, but they are decided by the municipalities. Methods and contents of check-ups vary depending on each municipality as well as the staff members involved in the check-ups. Most of the check-ups are conducted by a team of doctors (pediatricians & dentists), health nurses, nutritionists, and psychotherapists. Few municipalities include physiotherapists or occupational therapists in the team, who excel in knowledge and experience of motion development. There were occasional reports in recent years about the necessity and significance of the participation of physiotherapists in check-ups, but the situation still needs to be improved further (Uesugi et al., 2005). Children whose developmental disorders are clear can be identified through the present check-ups but those whose developmental disorders are minor, whose development is not in sequence, or who look normal at first glance tend to be missed. Physiotherapists can markedly contribute to identifying these children. They are knowledgeable about the primitive reflexes and motion development that follows, as mentioned above. They are capable of detecting abnormalities by observing the children's behavior.

It was identified in the questionnaire surveys conducted by Yamamoto during check-ups that mothers expected check-ups examination by doctors (50.2%), anthropometric & development inspection (39.4%), and childcare consultation (7.4%) (Yamamoto, 2000). This shows that many mothers desire anthropometric or development inspection. To meet their needs, it is necessary to include physiotherapists in the check-ups. At present, physiotherapists intervene only after disorders are suspected at check-ups and the doctors direct the intervention of a physiotherapist. There could be some weeks to several months' time lag before the intervention starts. In that case, required stimuli might not be given in a timely manner. It might take a long time before the intervention starts but it has to be done swiftly. This also supports the necessity of the involvement of physiotherapists in the check-ups, who can facilitate early detection and intervention for children with developmental disorders. Also, the New Motion Development Chart can be used as a screening test for developmental evaluation by physiotherapists with little experience in check-ups (Uesugi et al., 2005). An evaluation chart like this will enable physiotherapists who are not experienced with pediatrics to intervene successfully.

In this paper, children' physical development was described in general from a physiotherapeutic point of view. The principle of growth in sequence or children's manner of playing have changed, and it is important to understand that this affects normal development. It is necessary for conditions and staff members of the check-ups to be reviewed to promote ensure thorough attention and assessment. No growth stage can be skipped to ensure the normal development of children. It is important for children to learn each motion and function thoroughly for sound development. This is what all caretakers of children including mothers have to remember and reaffirm.

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