

Original Research

## Relationship between behavioral characteristics and motor coordination skills in early childhood

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### Abstract

Many studies have reported behavior problems of children attending kindergartens and nursery schools. Of the various reasons for such problems, motor performance is considered one possible factor. In this study, the background of behavioral characteristics was analyzed by measuring motor coordination skills of children aged between 4 and 6 years old who attend kindergartens and nursery schools. As the results, a significant difference was observed in motor coordination skill scores of children with hyperactivity / inattention, peer relationship problems, and prosocial behavior problems and those of children in a normal group. Understanding the background of children's behavior problems by measuring their motor coordination skills may enhance the comprehension of behavioral characteristics, suggesting the possibility of a major change in support for children in their early childhood.

**Key words** : early childhood, behavior characteristics, motor coordination skills

### 1. Introduction

The Ministry of Education, Culture, Sports, Science, and Technology reported in their survey<sup>1)</sup> that 6.5% of children studying in regular classrooms have learning difficulties or behavior problems despite the absence of an intellectual disability. Children with learning difficulties are defined as those who have marked problems with one or more of the following actions: "listening", "speaking", "reading", "writing", "calculating", and "reasoning". Children with behavior problems are defined as those who have marked problems with one or more of the following: "inattention", "impulsivity — hyperactivity", "interpersonal relationships", and "obsession". These problems are considered to be observed since early childhood. According to the study of Hirasawa *et al.*<sup>2)</sup>, of the 17,464 children from 143 nursery schools and kindergartens, 782 children

(4-5%) exhibited "worrisome / problem behaviors". Of these children, 18.0% had intellectual disabilities, 6.1% were diagnosed with disabilities other than intellectual disabilities, such as autism, attention-deficit hyperactivity disorder, and learning disabilities, and the remaining 75.8% were reported to be worrisome, but have not been diagnosed with any of the above disorders. According to Nakamura *et al.*<sup>3)</sup>, "worrisome children" were reported in 117 out of 196 nursery schools or kindergartens located in A Prefecture. A study by Abe<sup>4)</sup> also reported that 202 (2.9%) out of 6,892 preschool children attending nursery schools in western Japan were "worrisome", and 99 (39.6%) out of 250 classrooms had such children. In addition, Hongo *et al.*<sup>5)</sup> described the characteristics of such children as "being restless", "not being able to control one's emotions", and "often having troubles with other children" despite no marked delay in intellectual

development. As shown above, there are many children in kindergartens and nursery schools whose behavior is worrisome, and these reports showed that behavior problems observed in school-age children began since their early childhood. Although various factors are considered to contribute to the background of such problems, motor performance may be one possible factor which is closely involved with them.

Sugihara *et al.*<sup>6)</sup> examined in their study the relationship between the levels of motor performance and behavioral tendency of preschool children, and reported that preschool children with a high level of motor performance had high social communication skills. In addition, concerning the relationship between locomotor activities and personality traits, Sugihara<sup>7)</sup> reported that having less experience with locomotor activities had negative effects on the motivation and autonomy in male and on emotional stability in female children. Kasuga<sup>8)</sup> reported that preschool children with high cooperativeness had a high score in the standing long jump, 25-meter dash, and softball throw. Furthermore, studies, which involved children with autism spectrum disorders, reported that social communication skills and poor manual dexterity which are related to the formation of the character, are closely associated with the severity of their social skill impairment. According to Hirata *et al.*<sup>9)</sup>, Hilton *et al.*<sup>10)</sup>, and McDonald *et al.*<sup>11)</sup>, a strong correlation was observed between motor coordination and social impairment in children with autism spectrum disorders, and such children had low scores on the Movement Assessment Battery for Children II (MABC-II) which is used to evaluate motor skill development by the severity of social impairment. From these studies, the correlation between behavioral characteristics and motor performance was also confirmed.

This study aimed to objectively identify problems of pre-school children (aged between 4 and 6 years) using the Strength and Difficulties Questionnaire (SDQ), and to analyze the relationship between their behavioral characteristics and motor coordination skills using the MABC-II, which is used to assess the motor coordination. This study also aimed to clarify the characteristics of motor coordination skills of pre-school children with problems, by comparing a group of normal children and that of children in need of support divided by the results of the SDQ.

## 2. Methods

### 1) Subjects

The study subjects included 105 pre-school children aged 4 years (56 males and 49 females), 109 pre-school children aged 5 years (57 males and 52 females), and 86 pre-school children aged 6 years (38 males and 48 females), a total of 300 pre-school children (151 males and 149 females), who attend kindergartens or nursery schools and have no marked physical disability. The reason why we selected this age group was because: basic motor performance of children in their early-early childhood is not fully developed and varies among individuals, however, by late-early childhood, they begin to master basic physical skills, such as running, jumping, and throwing, which can be applied to the test items of the MABC-II.

### 2) Methods

To evaluate behavioral characteristics, we employed the SDQ which can objectively assess children's difficulties using 5 scales: "Conduct problem", "hyperactivity / inattention", "emotional symptoms", "peer relationship problems", and "prosocial behavior". In order to assess motor coordination skills, we employed the MABC-II to measure "manual dexterity", "aiming & catching", and "balance". Sub-items of "manual dexterity", "aiming & catching", and "balance" were as follows: "posting coins", "threading beads", and "drawing a trail"; "catching a beanbag" and "throwing a beanbag onto a mat"; and "one-leg balance", "walking with heels raised", and "jumping on mats", respectively. We requested homeroom nursery teachers to fill out the SDQ forms. The MABC-II was administered by 3 occupational therapists. The age, sex, and Kaup index were used as basic information. The survey was conducted between June 2014 and February 2015.

### 3) Methods of analysis

Based on a result of the SDQ, children with "low needs" and those with "moderate needs" or "high needs" were divided into a "normal group" and a "group requiring support", respectively. Scores for the MABC-II items and sub-items were compared between the groups using the Mann-Whitney U test. SPSS Ver. 20 was used for analysis.

### 4) Ethical considerations

Consent was obtained after explaining the

study purpose to directors of study facilities in an oral and to guardians of children in a written form. This study was conducted with the approval of the ethics committee of Osaka University of Comprehensive Children Education (Approval No. Jikenho-001). The data were discarded immediately after the study.

### 3. Results

#### 1) Characteristics of the subjects

Table 1 shows the mean and standard deviation of the age and Kaup index according to the sex. Kaup indices were compared between the age groups using the one-way ANOVA. As a result, the 4y-5y, 4y-6y, and 5y-6y differences were not significant ( $p < .931$ ,  $p < .905$ , and  $p < .996$ , respectively), showing that we extracted children with a standard body size.

#### 2) Comparison between the MABC-II and SDQ

##### (1) Comparison between the SDQ and MABC-II items

Table 2 shows the result of a comparison of the mean scores for the MABC items between the SDQ normal group and the group requiring support. Between the groups that did and did not require support concerning “hyperactivity / inattention”, “peer relationship problems”, and “prosocial behavior”, a significant difference was observed in manual dexterity ( $p < 0.007$ ) and balance ( $p < 0.002$ ); manual dexterity ( $p < 0.000$ )

and aiming & catching ( $p < 0.000$ ); and aiming & catching ( $p < 0.028$ ), respectively.

##### (2) Comparison between the SDQ and MABC-II sub-items

Table 3 shows the result of a comparison of the mean scores for the MABC-II sub-items between the SDQ normal group and the group requiring support. Between the groups that did and did not require support for “hyperactivity / inattention”, “emotional symptoms”, “peer relationship problems”, and “prosocial behavior”, a significant difference was observed in threading beads ( $p < 0.021$ ), drawing a trail ( $p < 0.017$ ), one-leg balance ( $p < 0.002$ ), and walking with heels raised ( $p < 0.035$ ); drawing a trail ( $p < 0.000$ ); posting coins ( $p < 0.001$ ), threading beads ( $p < 0.002$ ), throwing a beanbag onto a mat ( $p < 0.000$ ), and one-leg balance ( $p < 0.000$ ); and threading beads ( $p < 0.002$ ) and throwing a beanbag onto a mat ( $p < 0.001$ ), respectively.

### 4. Discussion

#### 1) Relationship between hyperactivity / inattention and motor coordination skills

SDQ questionnaire items regarding “hyperactivity / inattention” included: “Restless, overactive, cannot stay still for long” and “Easily distracted, concentration wanders” that indicate poor concentration and overactivity. In a comparison between the SDQ normal group and

Table 1 Age and Kaup index n=300

	boy			girl		
	n	age	Kaup index	n	age	Kaup index
4y (n=105)	56	4.07±0.03	15.31±1.11	49	4.07±0.03	15.50±1.29
5y (n=109)	57	5.05±0.03	15.16±1.27	52	5.05±0.04	15.55±2.31
6y (n=86)	38	6.04±0.05	15.18±1.27	48	6.03±0.07	15.17±1.32

Table 2 Comparison of the MABC-II items between the SDQ normal group and the group requiring support n=300

MABC-II three component			Manual Dexterity		Aiming & Caching		Balance	
			n	mean±SD	p	mean±SD	p	mean±SD
conduct problems	normal group	197	34.2±5.0	] n. s.	18.9±4.1	] n. s.	33.6±5.1	] n. s.
	supporting group	103	33.2±6.5		18.5±5.2		32.7±7.4	
hyperactivity/inattention	normal group	239	34.6±4.3	] **	18.9±4.4	] n. s.	34.1±4.7	] **
	supporting group	61	31.1±8.4		18.2±4.9		29.8±8.6	
SDQ item emotional symptoms	normal group	238	34.0±5.3	] n. s.	18.9±4.6	] n. s.	33.1±6.2	] n. s.
	supporting group	62	33.1±6.4		18.2±4.0		33.9±5.0	
peer relationship problems	normal group	204	34.6±4.8	] ***	19.4±4.4	] ***	34.1±5.3	] ***
	supporting group	96	32.1±6.7		17.3±4.5		31.5±6.8	
prosocial behaviour	normal group	159	34.7±4.2	] n. s.	19.4±4.2	] *	34.1±4.7	] n. s.
	supporting group	141	33.1±6.5		18.2±6.5		32.5±6.8	

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

the group requiring support, a significant difference was observed in threading beads and drawing a trail (manual dexterity), and one-leg balance and walking with heels raised (balance). Threading beads is a task in which children thread beads onto a string while coordinating their both hands, and the time required to complete it is measured. Drawing a trail is a task in which children draw a line without crossing boundaries. These two tasks require the coordination, dexterity, and accuracy of the upper limb in a static sitting posture. Posting coins also requires the dexterity of the upper limb. However, this task was performed with one hand, thus no significant difference was noted. One-leg balance requires to maintain a static posture, and walking with heels raised is a task in which children walk in a straight line with heels raised without stepping off the line. These two balance tasks require motor control in a dynamic balance. Whereas, jumping on mats is a task which requires dynamic balance. As in the questionnaire items about hyperactivity / inattention, maintaining a static posture is essential in order to sit still and get concentrated, thus resulting in a significant difference in the two static balance items.

Hyperactivity / inattention are one of the main symptoms of attention deficit and hyperactivity disorder. Kobayashi<sup>12)</sup> reported in his study that, as the characteristics of motor performance, children with attention deficit and hyperactivity disorder sometimes exhibit the signs of developmental coordination disorder, such as poor dexterity and balance. He also reported that such children generally have difficulties performing physical activities, and their ability to perform perceptual activities, particularly ball games which involves the eye-hand and eye-leg coordination, is less than half the level of that of healthy children. In the study of Kusunoki *et al.*<sup>13)</sup>, they also reported that many of the children with attention deficit and hyperactivity disorder exhibit a combination of characteristics : problems with gross motor coordination and poor manual dexterity in fine motor tasks. The results of this study were similar to those of Kobayashi<sup>12)</sup> and Kusunoki *et al.*<sup>13)</sup>, and multiple tests about balance and fine motor skills conducted in this study could identify more details about motor coordination problems.

During an occupational therapy session conducted previously with children with hyperactivity / inattention, the authors requested the children to perform a gross motor activity task to

Table 3 Comparison of the MABC-II sub-items between the SDQ normal group and the group requiring support

MABC-II three component		Manual Dexterity						Aiming & Catching				Balance					
using the test		Posting Coins		Threading Beas		Drawing Traial 1		Catching Beanbag		Throwing Beanbag onto Mat		One-Leg Balance		Walking Heels Raised		Jumping on Mats	
	n	mean±SD	p	mean±SD	p	mean±SD	p	mean±SD	p	mean±SD	p	mean±SD	p	mean±SD	p	mean±SD	p
conduct problems	normal group	197	11.3±2.3	n.s.	12.2±2.8	10.8±2.0	n.s.	10.0±2.6	9.0±3.1	8.7±3.4	n.s.	11.6±2.6	n.s.	11.0±2.3	n.s.	10.9±2.4	n.s.
	supporting group	103	10.9±2.6	n.s.	12.2±2.8	10.1±3.0	n.s.	9.8±3.0	8.7±3.4	8.7±3.4	n.s.	11.1±3.2	n.s.	11.0±2.9	n.s.	10.6±2.8	n.s.
hyperactivity/inattention	normal group	239	11.3±2.1	n.s.	12.4±2.6	10.9±1.8	**	9.9±2.6	9.0±3.1	9.0±3.1	n.s.	11.8±2.6	**	11.3±2.0	*	11.0±2.2	n.s.
	supporting group	61	10.4±3.2	n.s.	11.4±3.2	9.3±3.9	**	9.8±3.3	8.3±3.5	8.3±3.5	n.s.	10.2±3.4	**	9.7±3.8	*	9.9±3.5	n.s.
SDQ emotional symptoms item	normal group	238	11.2±2.3	n.s.	12.1±2.8	10.8±2.2	***	10.1±2.8	8.9±3.3	8.9±3.3	n.s.	11.3±2.9	n.s.	11.0±2.7	n.s.	10.8±2.6	n.s.
	supporting group	62	11.0±2.7	n.s.	12.4±3.0	9.5±3.1	***	9.4±2.5	8.8±2.9	8.8±2.9	n.s.	11.9±2.5	n.s.	11.2±1.9	n.s.	10.8±2.3	n.s.
peer relationship problems	normal group	204	11.5±2.1	***	12.5±2.7	10.7±2.1	n.s.	10.1±2.7	9.4±3.2	9.4±3.2	***	11.9±2.6	***	11.2±2.0	n.s.	10.9±2.2	n.s.
	supporting group	96	10.3±2.8	***	11.5±2.8	10.3±3.0	n.s.	9.6±2.9	7.8±3.0	7.8±3.0	n.s.	10.5±3.0	***	10.5±3.3	n.s.	10.4±3.1	n.s.
prosocial behaviour	normal group	159	11.3±1.9	n.s.	12.8±2.3	10.7±2.0	n.s.	10.0±2.5	9.5±3.1	9.5±3.1	***	11.9±2.5	n.s.	11.0±2.3	n.s.	11.1±1.9	n.s.
	supporting group	141	11.0±2.7	n.s.	11.6±3.1	10.4±2.8	n.s.	9.9±3.0	8.4±3.2	8.4±3.2	n.s.	11.1±3.1	n.s.	11.0±2.7	n.s.	10.4±3.0	n.s.

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

increase the stability of the trunk as a dynamic approach to motor coordination, before they sit down to perform table top activities. After performing this task, they settled into their seats to work on their assignment. The results of this study supported the relationship between the stability of the posture, which has been practiced by the authors, and the fact that the children could settle into their assignment. To use the fingers, it is necessary to maintain a stable sitting posture. To achieve this posture, we need to increase the muscle tension and balance the trunk to stabilize the posture. The stabilization of the posture can allow us to perform a spatial operation of the upper limbs to move and extend the arms outward to sides of the body trunk, and helps us exert the ability of dexterity to operate fingers. This posture stabilization helps us concentrate on activities. We consider that children's behavior problems, such as "restless, overactive, cannot stay still for long" and "easily distracted, concentration wanders", are caused because they have an unstable posture and poor control of their hands, legs, and body.

## **2) Relationship between emotional symptoms and motor coordination skills**

SDQ questionnaire items regarding emotional symptoms included: "Often complains of headaches, stomachaches, or sickness", and "Many worries or often seems worried". Although no significant difference was observed in manual dexterity between the SDQ normal group and the group requiring support, a significant difference was observed in its sub-item, drawing a trail. Drawing a trail is a task in which children draw a line without crossing boundaries. This task, which requires manual dexterity, creates tension for children, as they can easily understand when they fail. The SDQ items are related to tension or worries. Although no problem was considered with regard to manual dexterity since no significant difference was observed in the manual dexterity item, excessive worries and tension may have affected a low score for drawing a trail.

## **3) Relationship between peer relationship problems and motor coordination skills**

SDQ questionnaire items regarding peer relationship problems included: "Has at least one good friend", "Rather solitary, prefers to play alone", and "Gets along better with adults than with other children". In a comparison between the SDQ normal group and the group requiring support, a significant difference was observed in

posting coins and threading beads of the manual dexterity item, throwing a beanbag onto a mat of the aiming & catching item, and one-leg balance of the balance item. Hasegawa<sup>14)</sup> reported that children with poor motor performance have difficulties communicating with friends, and they often follow other children's lead or prefer to play alone. Sugihara *et al.*<sup>6)</sup> also reported, in their study, that a reduction in locomotor activities has an impact on motor performance, interpersonal relationships, and personality development. From these studies, the effects of locomotor activities on peer relationship problems were indicated. The results of the questions on peer relationship problems showed the possibility that children in the group requiring support have difficulties proactively getting involved with children of the same age. In order to play favorably with friends, an appropriate sense of distance or motor performance to favorably interact with friends is considered essential. For example, having the ability to run at approximately the same speed as other children helps them have fun in tag games, and it can also make friends feel pleasant and comfortable to play together.

However, if children have a problem with motor performance, it makes it difficult for them to play with or share the same space with other children, possibly making them and their friends less enjoyable. Due to this reason, children with such a problem may exhibit behaviors described in the SDQ questionnaire items, such as preferring to be alone or getting along better with adults. In order to perform the tasks of one-leg balance, posting coins, threading beads, and throwing a beanbag onto a mat, it is necessary to control one's own body well. To control the body, the body schema or postural stability, which involves vestibular, proprioceptive, and visual systems, are essential. The body schema is composed of: spatial properties that perceive physical factors of the body, such as the shape of the body surface and a boundary between the body and the external environment; and functional properties that control functional factors of the body, such as the posture and balance. Tactile sensations are reported to be involved in spatial properties, and proprioceptive and vestibular sensations in functional properties<sup>15)</sup>. These properties facilitate us to get involved with other people or the external environment in an unconscious manner. However, if the body schema is impaired, it makes it difficult to: interact with people, objects, and the environment in an unconscious manner, control

one's own body, and maintain an appropriate distance with other people. One-leg balance, posting coins, and threading beads require the ability to control one's own body, and throwing a beanbag onto a mat requires the ability to adjust the distance between the self and an object. The impairment in these abilities may affected peer relationship problems of the subjects.

#### 4) Relationship between prosocial behavior and motor coordination skills

SDQ questionnaire items regarding prosocial behavior included: "Consideration of other people's feelings", "Helpful if someone is hurt, upset, or feeling ill", and "Often offers to help others". Prosocial behavior is defined as "emotions or actions that are intended to understand and share the feeling of others, and to give priority to others rather than the self"<sup>16)</sup>, and the descriptions of the behavior to help and benefit other people by understanding situations were included in the SDQ items. In a comparison between the SDQ normal group and the group requiring support, a significant difference was observed in throwing a beanbag onto a mat (aiming & catching). Tomura<sup>17)</sup> reported in his study that children with a high motor performance have a favorable adaptation to the self as well as society. Prosocial behavior refers to voluntary emotions or actions toward others that require the ability to control one's own body to act with considerations for others, and to be mindful to the distance with and feelings of others. Throwing a beanbag onto a mat is a task which requires the skill to coordinate the distance between the self and an object, showing the similarity in the need for a sense of distance. Watanabe *et al.*<sup>18)</sup> stated that, in order for children to acquire interpersonal communication or social skills, it is necessary that they spontaneously acquire them while interacting with others through leisure activities, and have the experience of making spiritually-rich connections with objects or people using the five senses. However, if children have problems with motor coordination skills as observed in our results, they cannot play physical or play-based activities using their body, or control their own body when interacting with other children in play-based activities. This in result reduces their opportunities to make spiritually-rich connections with people or objects, possibly contributing to difficulties determining the distance and building relationships with others.

## 5. Conclusions

This study analyzed the background of behavioral characteristics, based on motor coordination skills of children aged between 4 and 6 years old who attend kindergartens or nursery schools, using the SDQ and MABC-II. Although many so-called "worrisome children" were reported in kindergartens or nursery schools, the judgement of whether or not they need support was difficult, and the identification of "worrisome children" was often based on subjective views of adult people. The results of this study showed a significant difference in MABC-II scores between the normal group and the group which requires support with regard to hyperactivity / inattention, peer relationship problems, and prosocial behavior, revealing motor performance problems in the latter group. Not identifying "worrisome children", but understanding motor performance of children based on their behavior may promote the understanding of behavioral characteristics, and may contribute to a major change in support for children in their early childhood. Understanding the meaning of physical and play-based activities when interacting with children in early childcare settings can promote their development. The results suggest that providing children with opportunities to participate in developmentally-appropriate physical and play-based activities while understanding their significance can promote their motor performance, which is the foundation of various types of behavior, improve their restless attitudes towards assignment, and help them interact and build relationships with other people.

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