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Dohsa-hou as a development of coordination for children with physical disabilities

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Abstract

Dohsa-hou was originally developed as an interventional method to facilitate movement in persons with cerebral palsy, but it has now become an important psychological method for rehabilitation and clinical results. This article aims to examine Dohsa-hou from the perspective of the development of coordination referred to as trends of action (Reed, 1988) and coordination (Bernstein, 1996). Focusing on coordination development, the author proposes the following: 1) the schema of body dynamics used in Dohsa-hou frames human movement in terms of psychological degrees of freedom, 2) the procedures of the Tate system of Dohsa-hou (Naruse, 1989) can be explained as the freezing and release of degrees of freedom of movement, and 3) balancing the body axis can be described in terms of reactive phenomena. By explaining the procedures of Dohsa-hou from the perspective of the development of coordination, the clinical practice of Dohsa-hou can be conveyed to more people more clearly and situated in an academic context.

Key words : Dohsa-hou, movement, coordination, degrees of freedom, action.

I. Introduction

Although the term of "Dohsa" expresses movement in Japanese, Naruse (1973) attributes a special meaning to this word in the context of psychology. The concept of "Dohsa" indicates a holistic process of motor action comprising the inner psychic activities and bodily movement. When we intend to move some parts of body, we strive to realize the bodily movement according to our own intention. If the striving is appropriate to the movement, the intended movement can be realized. Although "Dohsa" appears as bodily movement, it also includes the inner psychological activities such as intention and striving. The term of "hou" means method. Thus, "Dohsa-hou" is original Japanese method of psychological rehabilitation.

Dohsa-hou, originally developed for the psychological rehabilitation of those with physical disabilities such as cerebral palsy (e.g., Harizuka, 1992; Yamamoto & Hoshikawa, 2013), came to be utilized as an interventional method of development for those with mental retardation and autism (e.g., Konno, 1992; Matsuoka & Hoshikawa, 2014) and as a method of psychological therapy for those with mental illnesses (e.g., Tsuru, 1992; Fujioka, 1992). This article aims to examine Dohsa-hou from the perspective of the development of coordination.

When Dohsa-hou was first developed, human behavior in psychology was described, under the assumptions of Behaviorism, as a chain of stimulation and reaction. Naruse (1973) defined Dohsa-hou as the process of "intention - striving - body movement" underlying living human movement. Today, many psychologists believe, as a matter of course, that living humans have intention. The use of the word "intention" as an explanation for human movement in Dohsa-hou was, thus, half a century ahead of its time.

In the field of motor control, researchers had focused on movement as independent from the reflex hierarchy model or from central nervous control (Kudo, 2000). Before Bernstein (1967, 1996), human movement had been accepted and explained in terms of the inner central nervous system. After Bernstein proposed "activity physiology," the term

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"movement" came to be used to describe daily human life.

Thus, intentionality is today considered a part of psychology, as is its role in human movement in the field of motor control. Therefore, this article intended to focus, from the perspective of the development of coordination, on the role of Dohsa-hou in treating physical disabilities. If Dohsa-hou is defined both in lay and academic terms, many more people will be able to easily understand its clinical benefits.

II. From motor control to action and coordinative structure

In the psychology of the 1980s, acting and perceiving were regarded as completely separate areas of research. Perceiving was studied in the areas of cognition or sensation in psychology as an afferent process in which information is received from the external world. On the other hand, acting has been studied in the areas of motor control or physiology as an efferent process by which the body manipulates the external world. Early studies of human movement involved motor systems theories such as motor control, motor learning, and motor development (Reed, 1988). Until the 1970s, many motor theories such as the motor program (Keels, 1968), the closed-loop theory (Adams, 1971), the schema theory (Schmidt, 1975), and space coordinate systems (Lashley, 1951), were born. However, these motor system theories, for the most part, had been building mechanisms citing and referring to the findings of neurophysiology, such as simple pointing tasks using single-arm movement in adults (Reed, 1988). Therefore, it was not possible to use motor systems theory to describe human movement in everyday life.

Gibson (1979) objected to the dichotomy between acting and perceiving. Gibson proposed that perceiving and acting are closely related because people can perceive an object's location as well as their own in the environment according to the optical flow pattern of the environment driven by their own movement. Applying Gibson's idea of an ecological approach to action, Reed (1982, 1988) proposed action systems theory. The ecological approach, as typified by direct perception, has eliminated the mechanisms and representations of cognitive psychology and motor systems theory, and has rescued functional phenomena, such as evolution, adaptation, and pragmatism, from the errors of Behaviorism (Gibson, 1982; Turvey et al., 1981).

Reed (1988) argued that action consists of posture and movement. Posture is the persistent orientation of an organism in the environment, and movement comprises the specific changes in posture organized by agents while effecting particular changes in the relation between the organism and environment (Reed, 1988). Reed proposed that movements are nested into postures, and suggested that, because postural compensations were not observed in patients with cerebral palsy, such patients exhibit a failure of functional nesting. Moreover, Reed emphasized ecological description and classified seven basic acts underlying the human action systems. In his article, Reed (1988) focused on the skill of eating because of its psychosocial as well as nutritional importance to the individual and its practical and economic relevance to the management of chronic care in hospitals and the home.

For researchers in Dohsa-hou, action systems theory is easy to accept because it originated from the common concern of rehabilitation for patients with cerebral palsy. However, action systems theory merely classified acts, and it has been criticized for taking the discussion for granted. The question remains of how well ecological description can account for human motor development, because Reed merely described the typical movement of healthy people, not how movement in areas such as sports and tool use are acquired. Reed concluded that "learning a skill is learning how to use the affordances of the environment, not how to move one's body" (Reed, 1988, p. 80). He was only interested in the interaction between the environment and organism, and did not mention how a person moves their body. If an explanation of human movement does not include how to move one's body, it will not be able to explain movement in sports such as gymnastics. Therefore, a theory of movement needs to account for how one moves one's body in its explanation of the development of movements.

The idea of coordination came to be utilized in areas of sports such as baseball hitting (Katsumata, 2007) and learning to ski (Vereijken, Van Emmerik, Bongaardt, Beek, & Newell, 1997), and in motor development areas such as reaching (Yang, Scholz, & Latash, 2007). Bernstein (1997) argued that “coordination is overcoming an excessive degree of freedom of our movement organs, that is, turning the movement organs into controllable systems” (p. 41). Bernstein (1967) called this process “practice without repetition”: It is not the acquisition of a pattern of movements, but the functional organization of whatever postures and movements serve to get the job done. According to Bernstein, motor skill is the ability to solve one or more types of motor problems, not a movement formula and certainly not a formula involving permanent muscle forces imprinted in some motor center.

By capturing motor skills in this way, it will be possible to discuss the role of Dohsa-hou in the development of coordination.

III. Dohsa-hou in the development of coordination

1. The schema of body dynamics as an indication of the degrees of freedom

Bernstein (1967) described the 19th-century model of motor control as the “little man inside the head” playing a score on the keyboard of the cortex (Turvey, Fitch, & Tuller, 1982). When the little man controls his arm, he has to determine the values of the seven degrees of freedom to be simultaneously regulated on a joint level, 26 degrees of freedom on the muscle level, and 2600 degrees of freedom on the motor unit level. Turvey et al. described three of the major features of the 19th-century model of motor control as follows: “Firstly, there is no feedback in the account; the system is open-loop and insensitive to changes in external conditions. Secondly, the style of control can be characterized as address-specific, individualized control. The homunculus (and motor program) must specify values for each individual variable. And thirdly, the keyboard model assumes that the vocabularies of the motor program, the cortex, the spinal machinery, and the motor apparatus stand in one-to-one correspondence” (p. 244). In this model, it is no longer possible to explain human movement with a description of the little man, because it is difficult just to control the one arm. Bernstein pointed out the problem of the degrees of freedom and the problem of context-conditioned variability (Turvey, Fitch, & Tuller, 1982). Although the change accompanying learning can increase or decrease the dimensions and the mechanical degrees of freedom depending on the relevant changes required in the intrinsic dynamic of the task, the problem of degrees of freedom is the most common one in motor learning (Newell & Vaillancourt, 2001).

Naruse (1966) described the movements of children with cerebral palsy in various situations without invoking cerebrum physiology and neurophysiology. In Dohsa-hou, a schema of body dynamics consisting of 13 body parts is used to express the tension and form of the body (Naruse, 1997; See **Fig.1**). Because the 13 body parts in the schema of body dynamics easily indicate the characteristics of children’s posture and movement, the schema of body dynamics can be used as a method for assessing the distortion of their posture and their chronic tension. An expert trainer of Dohsa-hou can capture the characteristics of a subject’s body from the perspective of body dynamics. For

Number of Joints
1. neck
2. scapula
3. breast
4. back
5. waist
6. hip
7. knee
8. ankle
9. toe
10. shoulder
11. elbow
12. wrist
13. hand

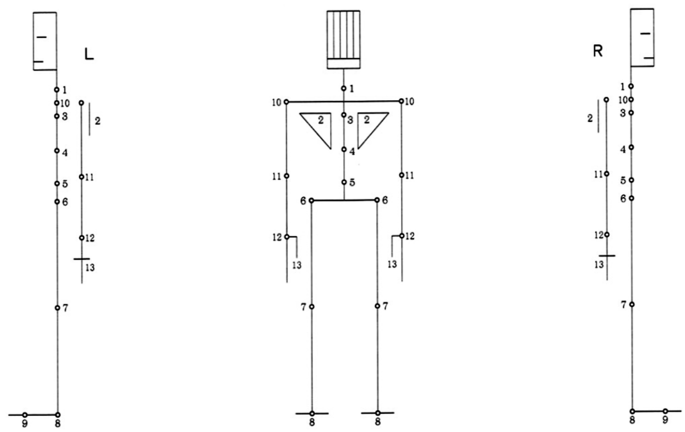

Fig.1 Schema of Body Dynamics (cited from Naruse, 1997)

example, a posture of protruding the buttocks can be described as the subject pulling No. 6 (the hip joint) backward. Moreover, we can easily capture the characteristics of posture and movement of those without disabilities depending on the schema of body dynamics. Therefore, it is also a psychological assessment method for capturing human movement, because states of the heart of a subject can be expressed by the schema. The 13 parts in the schema of body dynamics do not merely describe physiologic joints, but also psychological degrees of freedom. Although No.11 (elbow) and No.12 (wrist) are equivalent to physiologic joints, parts of the trunk (Nos.2, 3, 4, 5, and 6 in the schema of body dynamics) are not equivalent to physiologic joints. We can easily capture and discern the body's characteristics from a psychological point of view, because the schema of body dynamics can describe the movement of a living person.

2. An explanation of Dohsa-hou procedures of coordination

How can motor learning and the development of a person's movement be explained without physiologic explanation? Bernstein (1967) developed his own formulation of the stages of motor learning and development. Newell (1996) summarized Bernstein's proposals for changes in motor learning, based on his levels of movement construction, as follows:

Stage 1: Freezing Degrees of Freedom: Because the basic problem of coordination is the harnessing of the extreme abundance of degrees of freedom of the system, the first stage in learning is characterized by coordination solutions that reduce the number of degrees of freedom at the periphery to a minimum. This freezing strategy effectively reduces the number of biomechanical degrees of freedom that need to be coordinated and controlled.

Stage 2: Release of Degrees of Freedom : The second stage is characterized by the release of the ban on the degrees of freedom, that is, releasing the freeze on the constrained degrees of freedom. Eventually, the coordination solution of a skilled performance will incorporate all possible degrees of freedom at the periphery.

Stage 3: Use of Reactive Phenomena: The most advanced stage of motor learning corresponds to the system's utilizing entirely the reactive phenomena that arise from the interaction of the organism with the environment. In this stage, the coordination solution exploits, rather than resists, for example, the reactive torques of intersegmental coupling. This acquired functional use of the reactive torques also reduces the perceived and actual effort of movement production (p. 413).

With regard to the development of coordination, Bernstein considered that a car traveling forward is equipped with a kind of constraint, as the four wheels do not move freely (Tuller, Turvey, & Fitch, 1982). Analogously, Bernstein argued that when a person moves his or her own body, the person is capable of operating with fewer degrees of freedom, since movement is based on equations of constraint rather than the free movement of each joint. For example, a person just starting to learn a skill will simplify the parameter of degrees of freedom to a few degrees and hold most of the body rigidly. As the person becomes more skillful and releases their inhibition to freedom of movement, the additional degrees of freedom increase. In summary, in the process of acquiring a skill, a person freezes the fundamental degrees of freedom, then releases them through experience, and finally finds a way to use the skill (Tuller, Turvey, & Fitch, 1982). Thus, without specifying the values of individual muscles, the structure that acts as a unit of one degree of freedom is a coordinative structure.

Newell (1986) noted that discussion of the development of coordination was framed in terms of the maturation versus learning debate. He noted that the optimal pattern of coordination and control for a given individual was specified by the interaction of organismic, environmental, and task constraints. The relative impact of these three categories of constraint on the pattern of coordination varies by specific situation. In summary, the emphasis on constraints in the coordinative structure perspective offers a firm theoretical base for reexamining the traditional notions of motor development. In particular, the perspective of constraints forces a different interpretation of both the developmental movement sequence and the traditional distinction between phylogenetic and ontogenetic activities. Arising from such a reexamination is the notion that the principles of the development of coordination may cut across classes of activity and the developmental maturity of the individual. Moreover, Newell et al. (1989) outlined an approach for examining the exploratory behavior individuals use to master redundant biomechanical degrees of freedom while acquiring the "form" of movement coordination patterns. They focused on the search strategies used to explore and locate stable equilibrium regions or attractor in the perceptual-motor workspace.

In this way, the problem of moving one's body can be better captured from the perspective of the development of coordination, because this idea is thought to have ecological validity and is also verifiable. We will discuss Dohsa-hou from the perspective of the development of coordination in the following section. In particular, the Tate system of Dohsa-hou (Naruse, 1989) will be discussed from the perspective of the development of coordination. Specific guidance procedures are based on Naruse (2001). The Tate system of Dohsa-hou has five fundamental tasks. This article focuses on the sitting training task. The procedure of the sitting training task is as follows:

Step 1: Forming the posture pattern of the body: Using the trainer's hand/body to form the most suitable posture for training.

The basic posture for sitting training is a cross-legged sitting posture. The trainer first makes the trainee sit cross-legged. If the trainee has tension in No.6 (the hip joint) and cannot put his or her thighs on the floor, the trainer makes the trainee straighten his body parts between No.1 (neck) and No.6. When a bedridden child is placed in the sitting posture for the first time, the child often bends forward (**Fig.2-a**) or backward (**Fig.2-c**) with tension. In this task, the trainer helps the trainee create muscle tension in the parts of the body that are needed to remain vertical (**Fig.2-b**).

According to the perspective of coordination, in the bending pattern, the many degrees of freedom in the body create a situation of free movement, as if each movement is independent, not a conditioning to the context. Acquiring a sitting posture essentially means trying to find ways to control the degrees of freedom and exploit the forces made available by the context (Turvey, Fitch, & Tuller, 1982). If a trainer helps a trainee generate muscle tension in the vertical parts of the body, the trainee will be able to feel the upper body resting on his hips. In other words, the trainer will give the trainee the opportunity to explore stable equilibrium regions using the field of gravity.

Step 2: Relaxation by omakase: Getting the trainee to trust the trainer with his whole body and mind through sufficient relaxation.

In Step 2, a trainee must relax and entrust his whole body to the trainer. Specifically, it is necessary for the trainee's body to be passively moved into the position of the figure (**Fig.2-b**) by the trainer. In order for this to happen, the trainer must help the trainee be sufficiently relaxed around his hip joint in a recumbent position, as well as in parts of the trunk used in bending forward and backward in the sitting posture. Bernstein (1996) argued that relaxation is necessary for keeping the movement on track, and "is accompanied by a premium of enormous economy along all the lines of the physiological enterprise" (p.198).

Step 3: Putting the trainee's heart and soul into his body: Getting the trainee to stand independently through his body's own striving and trust his body and unconscious activity, and getting the trainee to stand up straight,

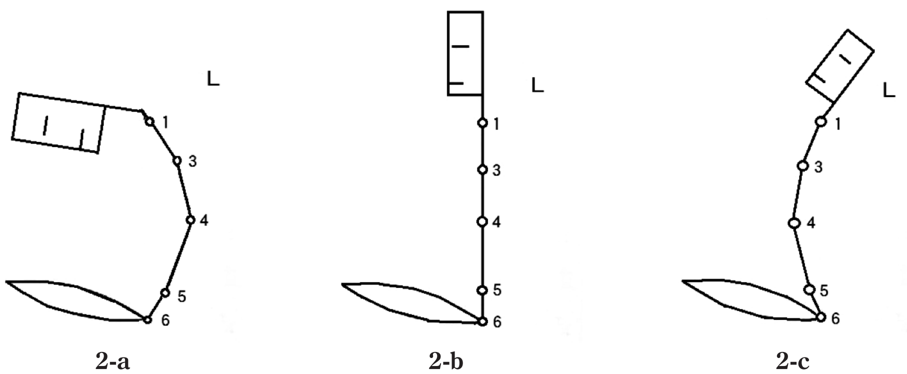

Fig.2 The direction of strength to bend forward, bend backward, and straight up

step down, and take a firm step on the ground.

After a trainer places a trainee's upper parts vertically in a sitting posture, the trainer releases his supportive hand from the trainee's body, saying "release my hold!" However, the trainer will not completely release his hand from the trainee. These steps help the trainee maintain an upright sitting posture.

If the trainee does not raise his head, the trainer will support the trainee's neck and shoulder. The trainer supports a trainee's back (No.3 breast) with his knee and places the trainee's head vertically on his back, and slightly increases his downward pressure on the trainee's shoulder, saying "release my hold!" In this intervention procedure, the trainee strives to hold a vertical posture. If a trainee strives to bend in the wrong direction with his head, such as forward or backward, the trainer will strengthen support with his supporting hand, and if the trainee keeps his head upright, the trainer will release his supporting hand (No.1 and No.3 relating training). This training helps the trainee keep his head upright. Using a similar support procedure, the trainer moves his knee as a support position from No.3 to No.4, to No.5, and to No.6. By reducing the amount of support gradually, the trainer helps the trainee keep the upper body upright.

The process of Step 3 can be described from the perspective of coordination. In the training related to No.1 and No.3, each of these locations serves as one of the two parameters for the degrees of freedom in the Tate system of training. A trainee easily focuses on these degrees of freedom, because the trainee's body parts below No.3 are supported by the trainer. When the trainee keeps his upper body upright, he does not need to choose the parameters for No.1 and No.3 since the degrees of freedom are frozen. While moving the supporting point downward, a trainee will be able to hold his upper body rigid like a stick. In other words, a trainee can freeze his degrees of freedom between No.1 and No.6, and explore his equilibrium region in context.

Step 4: Making the body a flexible axis: Getting the trainee to freely manipulate and balance his body axis on the ground, integrating the mind and all parts of the body through the entire activity.

Even if the trainee freezes his degrees of freedom and keeps his upper body vertical, he cannot maintain the sitting posture alone. If a trainee becomes upright, he will fall down as soon as the trainer releases his hand.

In Step 4, after his upper body is tilted by the trainer, the trainee returns his upper body to the original upright position. In other words, if to avoid falling the trainee braces himself by tilting the upper body forward, backward, right, and left, he can return his body to the original position without breaking his posture. As a result of Step 4, the trainee can independently maintain a sitting posture.

This process of Step 4 can also be described from the perspective of coordination. During the process of tilting forward, backward, right, and left, the trainee must keep his body straight. In other words, he must freeze his degrees of freedom between No.1 and No.6. This process is just Stage 3 of Bernstein's motor learning (the use of reactive phenomena). For example, if a trainee is tilted to his right side, his weight will be shifted to his right leg and right buttocks. If a trainee does not exhibit reactive power with the right leg and buttocks, he will fall to the right. However, if a trainee produces reactive power with his right leg or right buttocks through striving to do the same, he will maintain his tilted posture. Moreover, if a trainee produces torque using reactive movements, he will return his upper body to its original upright position.

Step 5: Forming a joint on the axis: Getting the trainee to move one or more flexible points on the body axis.

Even if the trainee can maintain a sitting posture alone, making the axis of the body flexible is necessary for standing and walking. The task of Step 5 is for the trainee to keep his upper body above No.5 upright and move No.5 forward and backward (**Fig. 3-a**, **Fig. 3-b**). Before mastering this task, the trainee will show the following error pattern: If the trainee's No.5 is moved backward, the trainee will bend his upper body forward (**Fig. 3-c**) or backward (**Fig. 3-d**), and if No. 5 is moved forward, the trainee will bend his upper body forward (**Fig. 3-e**) or backward (**Fig. 3-f**). This task involves two degrees of freedom of movement: No.5 and No.6. The author usually has the trainee maintain the No.6 position (position of pelvis) and asks him to move No.5 forward and backward (**Fig. 3-g** and **3-h**).

From the perspective of developing coordination, the trainee releases only degrees of freedom in No.5 and No.6, keeping the other body parts frozen. In the error pattern described above, the degrees of freedom were not frozen, and other body parts started moving freely on their own.

IV. Conclusion

In this article, the author explained Dohsa-hou in terms of the development of coordination (Bernstein, 1967), focusing on the Tate system of Dohsa-hou. This article focused on the following three points.

First of all, by describing the clinical procedures of Dohsa-hou from the perspective of the development of coordination, the clinical procedures of Dohsa-hou can be conveyed to many people more clearly. Recently, Dohsa-hou has not been used by special education teachers for independent activities in Japanese special supports schools because experienced teachers trained in Dohsa-hou have been retired in special supports schools. Thus, if the content of Dohsa-hou is understood by more teachers in special supports schools, they will apply Dohsa-hou to independent activities.

Secondly, by bridging Dohsa-hou and coordination, it is possible to view the clinical practice of Dohsa-hou more formally. Moreover, this will help researchers in experimental psychology and coordination take an interest in Dohsa-hou. In the future, the author expects that new, related research might emerge in the area of human movement.

Finally, Dohsa-hou can reproduce the process of typical development because children with cerebral palsy can acquire standing and walking postures through Dohsa-hou. Within approximately 18 months of birth, a child completes the process of phylogenetic development to walk. This process is very short, and a toddler cannot describe it verbally. Dohsa-hou can help a child with cerebral palsy develop his postures or movements. Yamamoto and Hoshikawa (2013) asked a subject with physical and mild mental retardation to describe his experience as part of the protocol for improving his posture by Dohsa-hou. In the future, we will be able to describe the process of phylogenetic development of children with cerebral palsy using Dohsa-hou.

Acknowledgments

The author dedicates this article to late Dr. Gosaku Naruse. Although the article still incomplete, it is my answer at this point to the task proposed by Dr. Naruse.

References

Adams, J.A. (1971) A closed-loop theory motor learning. *Journal of Motor Behavior*, 3, 111-149.

Bernstein, N.A. (1967) *The coordination and regulation of movement*. London: Pergamon Press.

Bernstein, N. (1996) On dexterity and Its development. In

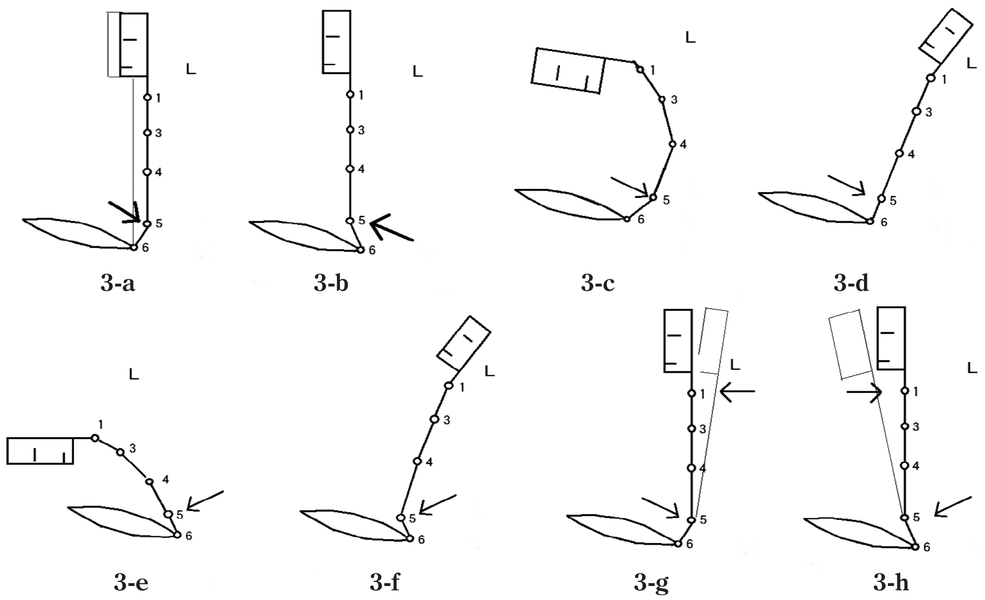

Fig.3 The trainee's error pattern and support procedure in the task of making flexible axis of body

M.L. Latash, &M.T Turvey (Eds.) *Dexterity and its development*, Hillsdale, NJ: Lawrence Erlbaum, 9-244, (Original published in 1947).

Fujioka, T. (1992) Development and practice of Dohsa-therapy. *The Journal of Rehabilitation Psychology*, 17-19, 165-170.

Gibson, E.J. (1982) The concept of affordances in development: The renascence of functionalism. In W.A. Collins (Ed.), *The Minnesota symposia on child development. Hillsdale*, N.J.: Erlbaum.

Gibson, J.J. (1979) *The ecological approach to visual world. Boston*: Houghton-Mifflin.

Harizuka, S. (1992) Dohsa-hou for making sitting-posture with legs crossed. *The Japanese Journal of Rehabilitation Psychology*, 17-19, 27-33.

Katsumata, H. (2007) A functional modulation for timing a movement: A coordinative structure in baseball hitting. *Human Movement Science*, 26, 27-47.

Keele, S.W. (1968) Movement control in skilled motor performance. *Psychological Bulletin*, 70, 387-403.

Konno, Y. (1992) Principles and practice of the Dohsa-hou for autistic children. *The Japanese Journal of Rehabilitation Psychology*, 17-19, 97-102.

Kudo, K. (2000) Current issues and future perspective in motor control research. *Japanese Journal of Sports Psychology*, 27(1), 10-18. (in Japanese).

Lashley, K. S. (1951) The problem of serial order in behavior. In L.A. Jeffress (Ed.) *Cerebral mechanism in behavior.* The Hixon Symposium, New York: Wiley.

Matsuoka, M., & Hoshikawa, H. (2014) The effects of Dohsa-hou on the facilitation for initiative joint attention and declarative joint attention of a child with autism. *The Japanese Journal of Rehabilitation Psychology*, 40(1),1-13. (in Japanese)

Naruse, G. (1966) Nohsei-mahi shya no shinrigakuteki rehabilitation. I: shikan- koudou ni tuite. (Psychological rehabilitation for cerebral palsy. I: on relaxation behavior). *Archives of Educational Psychology, Faculty of Education, Kyushu University*, 11, 2, 33-46. (in Japanese).

Naruse, G. (1973) *Shinri Rehabilitation (Psychological Rehabilitation).* Tokyo: Seisin Shobo (in Japanese).

Naruse, G. (1989) *Tatekei Dohsa Kunren hou (Tate-system Dohsa-hou).* Institute of Psychological Rehabilitation. Fukuoka. (in Japanese).

Naruse, G. (1997) The clinical Dohsa-Hou for cerebral palsied persons. *The Japanese Journal of Rehabilitation Psychology*, 25, 1-7.

Naruse, G. (2001) *Dohsa Kunren (Dohsa Training).* Institute of Psychological Rehabilitation. Fukuoka. (in Japanese).

Newell, K.M. (1986) Constraints on the development of coordination. In M.G. Wade & H. T. A. Whiting (Eds.), *Motor development in children: Aspects of coordination and control.* 341-360. Boston: Martinus Nijhoff.

Newell, K.M. (1996) Change in movement and skill: learning, retention, and transfer. In M.L. Latash, &M.T Turvey (Eds.) *Dexterity and its development*, Hillsdale, NJ: Lawrence Erlbaum, 393-429.

Newell, K.M., Kugler, P.N., Van Emmerik, R.E.A., & McDonald, P.V. (1989) Search strategies and the acquisition of coordination. In S.A. Wallace (Ed.) *Perspectives on coordination of movement.* 85-122. Amsterdam: North-Holland

Newell, K.M., & Vaillancourt, D.E. (2001) Dimensional change in motor learning. *Human Movement Science*, 20, 695-715.

Reed, E.S. (1982) An outline of a theory of action systems. *Journal of Motor Behavior*, 14, 98-134.

Reed, E.S. (1988) Applying the theory of action systems to the study of motor skills. In O. G. Meijer, & K. Roth (Eds.) *Complex movement behaviour: 'The' motor-action controversy.* 45-86. Amsterdam: North-Holland.

Schmidt, R. A. (1975) A schema theory of discrete motor skill learning. *Psychological Review*, 82, 225-260.

Tsuru, M. (1992) Theoretical consideration of Dohsa-therapy. *The Japanese Journal of Rehabilitation Psychology*, 17-19, 159-163.

Tuller, B., Fitch, H. L., & Turvey, M.T. (1982) The Bernstein perspective: II. The concept of muscle linkage or coordinative structure. In J. A. S. Kelso (Ed.) *Human motor behavior: An introduction.* 21-62. LEA: Hillsdale.

Turvey, M. T., Shaw, R .E., Reed, E. S., & Mace, W. M. (1981) Ecological laws of perceiving and acting: in reply to Fodor and Pylyshyn (1981). *Cognition*, 9, 237-304.

Turvey, M.T., Fitch, H.L., & Tuller, B. (1982) The Bernstein perspective: I. The problems of degrees of freedom and context-conditioned variability. In J. A. S. Kelso (Ed.) *Human motor behavior: An introduction.* 21-62. LEA: Hillsdale.

Vereijken, B., Van Emmerik, R.E.A., Bongaardt, R., Beek, W.J., & Newell, K.M. (1997) Changing coordinative structures in complex skill acquisition. *Human Movement Science*, 16, 823-844.

Yamamoto, S., & Hoshikawa, T. (2013) The effects of Dohsa-hou to the posture and activities of daily living of a student with intellectual and physical disabilities. The *Japanese Journal of Rehabilitation Psychology*, 39(2), 19-34. (in Japanese).

Yang, J.F., Scholz, J.P., & Latash, M.L. (2007) The role of kinematic redundancy in adaptation of reaching. *Experimental Brain Research*, 176: 54-69.