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# TOWARD A THEORETICAL DEVELOPMENT OF PHYSICAL ACTIVITIES FOR CHILDREN WITH HANDICAPPED : MOTOR, MOVEMENT, AND ACTION.

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## Abstract

The purpose of the article is to describe a research paradigm of motor domain for children with handicapped conditions. After historical overview with of perceptual-motor theories, movement skill development and current perspectives on action are discussed. Purposeful movement approach is emphasized for the physical activities for the handicapped in order to accomplish a movement problem.

**Key words :** Handicapped conditions, motor development, movement education, action.

## Introduction

Not only motor development but also general physical activity of young children have received considerable educational attention in recent year. Especially, concerns and aspirations for children with handicapped, particularly mentally retarded and other children with learning problem, have been primary in directing our attention to movement and to the potential contributions of movement experiences in other aspects of development and education. Because of deficiency in some aspect of gross and fine motor development, these retarded children fail to explore and move about the environment, and thus, reduce sensory awareness and incidental learning.

The central focus in special education has been, however, on keeping to describe that the effectiveness of a remedial/therapeutic training program on the improvement of motor abilities is dependent on the tasks presented to the children. Despite well documented and justified pleas for moving beyond such descriptive research, there is a need for more of it in certain area. Most of the available data are quantitative in nature: how far, how fast, how high. Qualitative descriptions, however, are lacking. Also, a number of qualitatively different movements may produce the same quantitative score (DiRocco and Robertson, 1981). What is the relationship between qualitative and quantitative performance? It has been suggested that the movements of some handicapped populations are characterized by greater quantitative than qualitative deficits (Robertson and DiRocco, 1981). Similarly, Campion and Brown(1976) have argued that the study of the qualitative deficits of performance may shed light on the nature of human ability.

Research in motor development has benefited from technological advances in new and refined techniques for analyzing the qualitative aspect of motor behavior. While studies employing these techniques have provided valuable information, such as data on spontaneous motor control in babies (Thelen, 1985), and interception of moving objects by babies (von Hofsten, 1979), these point of view from action including in motor control and coordination has been a more important development. There has been a shift away from focusing on the tasks that children are performing to a focus on the children themselves as movers. Unfortunately, there is no specific research which had attempted to explain the performance of individuals with handicapped in terms of a given theory (Hoover and Wade, 1985). Also the number of research presentations at the meeting of Japanese Special Education Association has decreased gradually in recent years.

This review treats as subjects matter the main theoretical development for physical activities for children with handicapped leading to the adoption of the movement skill development model. Further, the purpose of this paper is to bring to the attention of practitioners and researchers the key role of movement skill in action systems, which emphasize the purposeful movement, and can be useful in teaching physical activities to children with handicapped conditions.

#### Historical overview

The origins of research interests in motor development were in the efforts of physicians and psychologists during the 1920s and 1930s to devise developmental scales. Observations of motor of infants and young children have been used as indicators of progress in development. Developmental scale, then (Gesell, 1940; Shirley, 1931; Bayley, 1935), relied heavily on observation of motor development during the first and second years of life because verbal and personal social skills were less well developed and more difficult to observe during these years. Interest in motor development was dormant during twenty-year period from 1940 to 1960. The few studies were along the lines of age-sex comparisons and physical growth correlates, and were the results of continuing interest of limited number of researchers.

A revived interest in motor development came in the wake of educational concern for children with learning problems. Although beginning with mentally retarded children, all types of educational concerns soon were included along with the involvement of a wide variety of professional personnel in education, medicine and psychology. Motor development is a key aspect of many theories or suggestions proposed to explain learning problems and movement experiences are included in many educational programs for children with learning problems. Speculation by psychologists about relationship of motor development and perceptual-cognitive development provided the main impetus for mind-body interactions and inadequacies.

Over 50 programs for perceptual-motor had been developed by the early 1970s (Austin, 1974). Three of the most influential perceptual-motor theorists were Kephart (1960), Frostig(1970), and Barsch(1967), whose programs had tremendous impact in the field of special education not only in the United States but also in Japan. Dr. Kobayashi, a leader in this movement in Japan, observed in one of his books based on Frostig's theory that "much of the motor problems of the handicapped child appears to

be due to lack of integration of perceptual and motor systems, as well as the failure of the visual perceptual processes to provide substantial and clearly structured patterns for the motor actions to follows"(1986).

Reid(1981) pointed that these rather oversimplified models postulated that motor experience and proficiency were prerequisite to optimal perceptual function, which in turn was prerequisite to cognition, including academic task such as reading and arithmetic. Most of the research studies in this area are inadequate in fundamental aspects of sampling, testing, designing and analysis; results are inconclusive or negative (Myers and Hammill, 1976). The decade of research in this area has provided little of theoretical and empirical value (Cratty, 1989; Keogh, 1978, 1979). Recently in U. S. A, the borad of Trustees of the Council for Learning Disabilities(1986) recommended "a moratorium on assessment and training of perceptual and perceptual-motor functions in educational programs" (p.247).

### A shift from motor to movement

As the perceptual-motor theories in the past tended to be descriptive, current researches and writing now look at children themselves and the process that occurs as they move. Many authors (Keogh and Sugden, 1985; Gentile, 1975; Curtis, 1987) have expressed view points in which children are seen as part of a dynamic interaction between themselves and their environment. Movement is seen as a process of change resulting from both internal and external influences, it is a dynamic component in young children's development. This change of focus is very compatible with current research and practices in young children.

Keogh and Sugden(1985) defines it as follows; Motor will refer to the internal motor system, and movement will be the an observable behavior than with internal motor functions. After all, movement is as seen as a results of the neuromotor system causing muscles to contract and limbs to move in timed sequences. Human interactions take place in a psychological as well as biological environment—the "inner surround," as the researchers of movement (Teeples and Williams, 1977; Keogh and Sugden, 1985; Curtis, 1987) refer to them. The "outer surround" is the traditional environment in which human beings move.

A movement skill is an organized sequence of movements directed toward a desired outcome. Movement of different body parts must be coordinated to produce a total movement, whether it be arm and hand movements to reach and grasp an object or more continuous leg and arm movements to walk across a room. A movement skill is also adaptive in terms of altering movement organization to adjust to different environmental conditions, as when walking uphill or downhill and on smooth or bumpy surfaces. Adaptive capability is also seen when using the same movement skill in different movement situations, whether it be turning a bolt in a threaded hole or turning a knob to dial a radio station (Keogh, 1977).

Movement skill problems of children range from complete lack of movement to general impressions that movements are not graceful or are ineffective. Included within these broad limits are children who are unable to walk or reach and grasp as well as those who have difficulty translating into movement what they see or imagine,

as when trying to copy figures or draw pictures, or who have difficulty adjusting to context changes, as when trying to catch a bouncing ball. Inadequate development of the neuromotor system and related biological support systems will limit the development of control of basic movements. Inadequate development of information processing capabilities, particularly of perceptual-cognitive skills, will make it difficult to adjust to environmental conditions and task requirements. A general division of personal resources and movement outcomes along these lines provides a framework for thinking about movement skill problems of children.

Sugden and Keogh(1990) illustrated two examples as common movement skill problems in children with handicaps which are movement stereotypies and hyperactivity ;

Movement stereotypies, which are common among autistic, blind, and mentally retarded children, include rocking, hand lapping, and similar rhythmical movement repeated in a cyclical manner. Movement stereotypies also are seen early in the development of many babies and young children, but not to a marked extent and not at older ages. Hyperactivity is a matter of a child moving too much, often at inappropriate times. Explanations for hyperactivity include inability to inhibit movement and leaning to use hyperactivity as a means of coping with personal-social and other environmental requirements. Movement stereotypies and hyperactivity are examples of problem of movement control (p.6).

Based on concepts of movement skill development theory, movement education (Motopedagogik) approach was devised by Kiphard (1979, 1983) and was originally intended for children aged 5 to 12 years who were emotionally disturbed, mentally retarded, physically handicapped, or in other ways disabled. Programs of this approach have been used for more than 20 years in the Germany and have shown good results especially in outpatient therapeutic interventions for children with handicapped conditions (Doll-Tepper, 1989). The component of this approach involve (a)training the sense such as touching, hearing, and seeing ; body schema exercises and exercises/ games involving body and spatial orientation ; (b)training self-control and carefulness, for example walking noiselessly, balancing exercises involving dexterity, (c)rhythmic and musical exercises/games including exercise/games in rhythmic and dynamic movement, and listening to and moving to music ; (d)training inventiveness and role-playing such as inventive activities/creative games, improvisation and imitation of animals, acting out situations, occupations, and so forth. Kiphard's approach emphasizes the importance of body experience as well as material and social experience through movement in order to improve the individual's competence-learning through movement. By improving movement ability, emotional stability is achieved, thus providing the child with a basis for further learning. The overall aim of this approach is to develop and further the capacity to act as independently as possible so that the child can usefully cope with him/herself and the environment (objects, materials, other people). Empirical and theoretical studies of movement skill problems have been concerned almost exclusively with the influence of movement experiences on perceptual development and

how changes in perceptual development lead to changes in cognitive development and related school achievement. However, very little attention has been paid to how changes in perceptual development lead to changes in movement skill development.

### The expansion from movement to action

A computer analogy is used to view a human as a self-regulatory system capable of receiving, processing, and transmitting information. The information processing approach focuses on the use of information to organize and adjust movements in relation to environmental conditions and task requirements. Movements are seen that organized on the basis of motor programs, which can be stored for future use and modified and extended by additional information.

Information processing capabilities thus became central in understanding how movement skill is controlled and modified in 1970s. The involvement of sensory, perceptual, and cognitive processes in human behavior is the fundamental concern in information processing, an approach that has dominated the study of movement skill over the last 20 years (Martenuik, 1976; Stelmach, 1976, 1978). Adams' servo-loop (after Craik, 1947) and errornulling ideas in his closed-loop theory (Adams, 1971) representing an electronic-like system are transformed into the cybernetic-like subroutines of schema theory (Schmidt, 1975).

Recently, there is a growing interest in the study of "action" instead of "movement" (Newell, 1981; Reed, 1982; Turvey, 1977; Whiting, 1980; Fres & Sabini, 1985). Information processing theories have been criticized because of their artificial character. That is to say, they are regarded as being derived from the simplistic movements of experimental subjects required to perform in an impoverished environment, often devoid of vision and confined to rather static and unnatural conditions (Newell, 1981). For example, the action perspective advanced by Turvey(1977) in the domain of motor skills can be seen as a reaction against the ubiquitous computer analog; we would be reminded that human beings are, after all, interacting with environments and not data processing machines.

The research approaches (Thelen, Kelso, and Fogel, 1987; Kugler, Kelso, and Turvey, 1982; Turver, 1977, 1990; Newell, 1992) will be discussed in terms of how one views the nature of movement skill development and what are likely avenue of research. The nature of movement skill development is what one views as the phenomena to be identified and understanding. Recent approaches to studying movement skill were identified by Kelso(1982), more dynamic approach than traditional one, which is action emerges from relationships governing the current state of involved systems and processes and existing environmental conditions and task requirements, rather than being a one-way or hierarchical organization that flows from information input to effector output. Such perspective of action is derived from the direct perception view of Gibson (1966, 1977) and the ideas of Bernstein(1967) about organization of movement.

Gibson proposed that information is directly perceived and does not need elaboration by the individual. Information is rich in itself and is composed of events that continuously unfolded (Reed, 1982). Events have a wholeness and totality, rather than

being a series of single instance images that need to be processed or transformed. The interaction between environment and individual is all important, with invariants specifying the persistent properties of the environment that the individual knows. The invariants specify objects, places, and events, but they cannot be considered separate from the individual. Gibson (1966, 1977) believes the environment affords actions that are relevant to the individual. An environmental situation containing a number of invariant will afford different actions to different individuals.

Utilizing an ecological perspective, Burton(1987) explained that movement problems often found in children with disabilities might, in some cases be due to problems in perceiving what the environment affords for action. In 1990, Burton suggested a possibility that developmental disabled children who have movement problems have the normal-like perceptual sensitivity to the relationship between their personal constraints and the constraints in the environment in a movement context. Block(1993) indicated that the children with mental retardation were able to accurately perceive the affordance for jumping distance.

On the other hand, Bernstein(1967) approached the problem of how movement is organized by focusing on the problem of how so many variables could be constrained into a behavioral unit. He proposed that organization, which he identified as coordination, depends upon limiting the degrees of freedom related to the many variables involved in producing a movement. As reviewing the researches of movement skill learning of mentally retarded individuals, Newell(1985) criticized these studies as dealing only with control and not with coordination and skill.

Thelen(1986), in her systems account of Bernstein's perspective, identified eight components or factors contributing to locomotor skill and proposed that some of these components are "rate-limiters" that constrain the emergence of locomotor behaviors. That is, even if all other components are ready to support bipedal locomotion in a given child, one or two rate-limiters that are not ready, such as postural control and extensor strength, would keep that child from beginning to walk. In this developmental context, Thelen(1986) emphasized the importance of identifying the components that are rate limiting in explaining the emergence of locomotor milestones. Similarly, when assessing children with movement problems, it is important to determine which specific components or factors are limiting or constraining their movement behavior. A list of important components or factors shaping and influencing the motor behavior of handicapped and nonhandicapped children should include body size/morphology, muscular strength, cardiovascular endurance, flexibility, perceptual accuracy, postural control, the degree of coordination between body components, and the degree of control over the coordinated units. The potential of some of these factors to act as rate-limiters in the movement behavior of handicapped children has been demonstrated (e.g., body size-Dobbins, Garron, & Rarick, 1981; motor control-Davis 1986), but there is little research that would prompt a practitioner to consider perception as possible rate-limiter of the action of a child with movement problems. Not only is information directly perceived, but organization of movement emerges from the dynamics of relationships governing the interplay of variables involved in perception and action, coordination thus is like an equation in which the outcome is a function of higher order rela-

tionships among variables, including the status of the variables. Movement emerges as the solution of an equation. That is, Bernstein(1967) noted, the organization of movement action can be considered as the solution of a movement problem. The individual is confronted with a problem, whether the sources of the conditions creating the problem be internal or external to the individual. According to Savelsbergh and Van der Kamp(1994), exploratory behavior which leads to an effective solution for a movement problem is very important in both the direct perception view of Gibson and Bernstein's perspective. The nature of movement skill development is, when an individual faces with the movement problems, the organization of the plan of action and the execution of the movement process.

### **Purposeful movement and handicapped individuals**

Matters with handicapped conditions become more complicated when including movement use as part of an action system, but action systems within the context of environmental consequences must be studied. As definition by Elliot and Connolly (1974) that movement skill is an "organization of actions into executed with economy (p.135)", a key to solve this complicated problem is the purposeful movement. Purposeful movement may be defined as movement activities involving an objective beyond the actual performance of the movement itself, that is, movement being performed as a means to an end, not as an end in itself (Gliner, 1985 ; Hinojosa, Sabari, Rosenfeld, & Shapiro, 1983).

In this context, then, purposeful movement changes the focus of performers from themselves and the movement being performed to environmental cues for moving and the higher level objective of the activity. Further, purposeful movement may be more motivating than nonpurposeful movement and may even result in greater physiological benefits than nonpurposeful activities. The importance of purposeful activities in remedial programming has been acknowledged by occupational therapists for many years (Gliner, 1985 ; Hinojosa et al., 1983) and has been supported by research reported in the occupational therapy literature (Kirchner, 1984 ; Steinbeck, 1986).

Kirchner(1984) had 26 female subjects perform rhythmical jumping with and without jump ropes and measured the heart rates at which they reached the subjective point of "very hard work" on the Borg Scale of Perceived Exertion (this usually relates to an actual heart rate of approximately 170 beats/min). In comparing the two conditions, she found that the heart rate increase and the amount of time taken to reach the given point of exertion was greater with the rope, suggesting that the women were working harder and longer at the same level of perceived exertion when the jump rope was used. Steinbeck(1986) reported similar results when male and female subjects were asked to pedal or squeeze a rubber bulb in both purposeful and nonpurposeful context until they were working "somewhat hard" (equivalent to a heart rate of about 130 beats/min on the Borg Scale). Yasui(1991) suggested that active jump training in purposeful context has more positive effect on the not only cardiovascular system but movement confidence than passive jump training on the trampoline for Down syndrome children.

A purposeful context may also be provided through sports and games in physical

activity for the children with handicapped. Auxter and Pyfer (1985) suggest there are two approaches to teaching adapted physical education; task-specific or "top-down," and developmental or "bottom-up." The task-specific approach involves teaching a specific skill directly, in as normal a context as possible, and moving down to work on general abilities or basic input/output systems only as is necessary for a particular skill. Conversely, the developmental approach being at the bottom (i.e., with basic input/output system), works up through general abilities, and teaches the student specific skills only after these building blocks are in place.

In order to provide the most purposeful setting possible, Burton(1987) recommends that the task-specific approach should be always considered first and the developmental approach used only in special circumstances.

### Conclusion

The main thrust of this paper has been to focus attention on theoretical development for motor domain of with handicapped in terms of role of action systems in organizing movement processes. Particular emphasis has been placed on the need to identify qualities and characteristics of movement processes in order to explain and to identify or infer mechanisms and their functioning. An important methodological consideration is that more sophisticated observation and analyses of action in real world and performance components will be required rather than the traditional use of performance data.

In connection with using more conceptual and theoretical formulation, researchers are using an earlier research methodology of making detailed observations of movements and related behaviors, although now as a means of identifying organizational qualities of movement process and inferring underlying mechanism and their functioning. The current emphasis upon understanding this process including in motor control and coordination is more conceptual and theoretical than were earlier approaches to studying movement skill development.

The perspective of action is derived from the direct perception view of Gibson (1966, 1977) and the ideas of Bernstein(1967) about organization of movement skill for children with handicapped, which order emerges from the dynamics governing relationships among relevant variables, which are presumed to be known directly. Dynamic interactions among the systems determine the course and quality of movement skill development. Our interest in the development of personal resources is that movement skill problems can be traced to inadequacies in development of personal resources, such as the neural limitation in cerebral palsy, which restrict basic control of posture, locomotion and manipulation, or loss of vision, which makes it difficult to use locomotor skills for traveling in the environment. This leads to a search for governing relationships that enable the many variables involved in movement to function in concert and is true particularly in extending the study of movement skill to include developmental issues.

## REFERENCES

- Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, **3**, 111-149.
- Austin, P. L. (1974). The role of physical education for children with learning disabilities. *CA-HPER Journal*, **41**, 6-10.
- Auxter, D and Pyfer, J. (1985). *Principles and method of adapted physical education and recreation (5th ed.)*. St. Luis: Times Mirror/Mosby.
- Barsch, R. H. (1967). *Achieving Perceptual-Motor Efficiency: A Space Oriented Approach to Learning*. Vol. 1. Seattle, WA: Special Child Publications, Inc.
- Bayley, N. (1935). The development of motor abilities during first years. *Monograph of the Society for Research on Child Development*, **1**, 1-26.
- Bernstein, N (1967). *The co-ordination and regulation of movements*. Oxford: Pergamon Press.
- Block, M. E. (1993). Can children with mild mental retardation perceive affordance for action? *Adapted Physical Activities Quarterly*, **10**, 137-145.
- Broad of Trustees of the Council for Learning Disabilities (1986). Measurement and training of perceptual and perceptual motor functions: A position statement by the Broad of Trustees of the Council for Learning Disabilities. *Learning Disability Quarterly*, **9**, 247.
- Burton, A. (1987). Confronting and interaction between perception and movement in adapted physical education. *Adapted Physical Activities Quarterly*, **4**, 257-267.
- Burton, A. (1990). Assessing the perceptual-motor interaction in developmentally disabled and non-handicapped children. *Adapted Physical Activities Quarterly*, **7**, 325-337.
- Campion, J. C. and Brown, A. L. (1976). Memory and metamemory developments in educable retarded children. In R. V. Kail & J. H. Hagen (Eds.), *Perspectives on the developments of memory and cognition* (pp. 285-301). Hillsdale, Nj: Erlbaum.
- Craik, K. J. W. (1947). Theory of the human operation in control systems, U. Man as element in the control system. *British Journal of Psychology*, **38**, 142-148.
- Cratty, B. J. (1989). *Adapted physical education in the mainstream (2nd ed.)* Denver, CO: Love Publishing.
- Curtis, S. R. (1987). New views on movement development and the implications for curriculum in early childhood. In C. Seefeldt (Ed.). *The early childhood curriculum: A review of current research*. New York, NY: Teachers College Press, Columbia University, 257-270.
- Davis, W. (1986). Development of coordination and control in the mentally handicapped. In H. T. A. Whiting and M. G. Wade (Eds.), *Trends in motor development* (pp. 143-157). Dordrecht: Martinus Nijhoff.
- DiRocco, P and Robertson, M. A. (1981). Implications of motor development research: The overarm throw in the mentally retarded. *The Physical Educator*, **8**, 27-31.
- Dobbins, D. A., Garron, R & Rarick, G. L. (1981). The motor performance of educable mentally retarded and intellectually normal boys after covariate control for differences in body size, *Research Quarterly for Exercise and Sport*, **52**, 1-8.
- Doll-Tepper, G. M. (1989). Children with special needs- Motodiagnostic test procedures and Kiphard's mototherapeutic approach. *Adapted Physical Activities Quarterly*, **6**, 170-175.
- Kobayashi, Y. (1986). The development of sensory-motor. In Y. Kobayashi and H. Hayashi (Eds.) *Motor development for children*. Tokyo: Coleru Pub. (Japanese)
- Elliot, J. M and Connolly, K. J. (1974). Hierarchical structure in skill development. In K. J. Con-

- noly & J. S. Bruner (Eds.), *The growth of competence*. New York : academic Press.
- Fres, M. & Sabini, J. (1985). *Goal directed behavior : The concept of action in psychology*. Hillsdale, NJ : Erlbaum.
- Frostig, M., Maslow, P (1970). *Movement education -theory and practice*. Chicago, IL : Follett.
- Gentile, A. M., Higgins, J. R. and Miller, E. A. (1975). The structure of motor tasks. *Movement*, **7**, 11-28.
- Gesell, A. and Amatruda, C. S. (1947). *Developmental diagnosis (2nd ed.)*. New York : Harper & Row.
- Gibson, J. J. (1966). *The senses considered as perceptual systems*. Boston : Houghton Mifflin.
- Gibson, J. J. (1977). The theory of affordances. In R. Shaw and J. Bransford (Eds.), *Perceiving, acting, and knowing ; Toward an ecological psychology*. Hillsdale, NJ : Erlbaum.
- Gliner, J. A. (1985). Purposeful activity in motor learning theory : An event approach to motor skill acquisition. *American Journal of Occupational Therapy*, **39**, 28-34.
- Hinojosa, J., Sabari, J., Rosenfeld, M. S., and Shapiro, M. S. (1983). Purposeful activities. *American Journal of Occupational Therapy*, **37**, 805-806.
- Hoover, J. H. and Wade, M. G. (1985). Motor learning theory and mentally retarded individuals : A historical review. *Adapted Physical Activity Quarterly*, **2**, 228-252.
- Kelso, J. A. S. (Ed.) (1982). *Human motor behavior : An introduction*. Hillsdale, NJ : Erlbaum.
- Keogh, J. (1977). The study of movement skill development. *Quest*. Monograph, **28**, 76-88.
- Keogh, J. (1978). Movement outcomes as conceptual guidelines in the perceptual-motor maze. *Journal of Special Education*. **12**, 321-29.
- Keogh, J. and Sugden, D. (1985). *Movement skill development*. Macmillan, New York, NY : 54-98.
- Kephart, N. C. (1960). *The slow learner in the classroom*. Columbus, OH : Merrill.
- Kiphard, E. J. (1979). *Motopedagogy*. Dortmund : Modernes Lernen.
- Kiphard, E. J. (1983). *Mototherapy*. Dortmund : Modernes Lernen.
- Kirchner, M. A. (1984). Motivation as a factor of perceived exertion in purposeful versus non purposeful activity. *American Journal of Occupational Therapy*, **38**, 165-170.
- Kugler, P. N., Kelso, J. A. S., and Turvey, M. T. (1982). On the control and co-ordination of naturally developing systems. In J. A. S. Kelso and J. E. Clark (Eds.), *The development of movement control and co-ordination* (pp.5-78), New York : Wiley.
- Marteniuk, R. G. (1976). *Information processing in motor skills*. New York, NY : Holt-Rineheart and Winston.
- Myers, P. I. and Hammill, D. D. (1976). *Methods for learning disorders (2nd ed.)*. New York, NY : John Wiley.
- Newell, K. M. (1981). Skill learning. In D. Holding (Ed.), *Human skills* (pp.257-269). London : Wiley.
- Newell, K. M. (1992). Prefer to the theme issue on dynamical approach to motor skill acquisition. *Journal of Motor Behavior*, **24**, **1**, 1-3.
- Reed, E. S. (1982). An outline of a theory of action systems. *Journal of Motor Behavior*, **14**, 98-134.
- Reid, G. (1981). Perceptual-motor training : Has the term lost its utility? *Journal of Health, Physical Education, Recreation and Dance*, **53**, 38-39.
- Robertson, M. A. and DiRocco, P. A. (1981). Validating a motor skill sequence for mentally retarded children. *American Corrective Therapy Journal*. **35**, 148-154.

- Savelsbergh, G. J. P and Van der Kamp, J. (1994). A natural physical perspective on the development of infant eye-hand coordination: A search for the lows of control. *Annual Report of Research and Clinical Center for Child Development* (pp.103-109), RCCCD, Faculty of Education, Hokkaido University.
- Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review*, **82**, 225-260.
- Shirley, M. (1931). *The first years: A study of twenty-five babies, 1. Postural and locomotor development*. Minneapolis; University of Minnesota Press.
- Steinbeck, T. M. (1986). Purposeful activity and performance. *American Journal of Occupational Therapy*, **40**, 529-534.
- Stelmach, G. E. (Ed.) (1976). *Motor control: Issue and trends*. New York; Academic Press.
- Stelmach, G. E. (1978). *Information processing in motor control and learning*. New York: Academic Press.
- Sugden, D. A. and Keogh, J. F. (1990). *Problems in movement skill development*. Columbia, SC: University of South Carolina Press, 68-112.
- Teeple, I. G. and Williams, H. G. (1977). Rate and level of learning as functions of information-processing characteristics of the learner and the task. *Journal of Motor Behavior*, **9**, 179-192.
- Thelen, E. (1985). Developmental origins of motor coordination: Leg Movements in human infants. *Developmental Psychobiology*, **18**, 1-18.
- Thelen, E. and Kelso, J. A. S and Fogel, A. (1987). Self-organization systems and infant motor development. *Developmental Review*, **7**, 39-65.
- Thelen, E. (1986). Development of coordinated movement: Implications for human development. In M. G. Wade and H. T. A. Whiting (Eds.), *Motor development in children: Aspects of coordination and control* (pp.107-124). Dordrecht: Martinus Nijhoff.
- Turver, M. T. (1977). Preliminaries to a theory of action with reference to vision. In R. Shaw and J. Bransford (Eds.), *Perceiving, acting and knowing* (pp.211-265). Hillsdale, NJ; Erlbaum.
- Turvey, M. T. (1990). Coordination. *American Psychologist*. **45**, 938-953.
- von Hofsten, C., and Lindhagen, K.(1979). Observations on the development of reaching for moving objects. *Journal of Experimental Child Psychology*, **28**, 158-173.
- Whiting, H. T. A. (1980). Dimensions of control in motor learning. In G. E. Stelmach and J. Requin (Eds.), *Tutorials in Motor Behaviors* (pp.537-551), Amsterdam: North Holland.
- Yasui, T. (1991) An analysis of heart rate and EMG pattern during the trampoline movement activity of children with Down syndrome. *Japanese Journal of School Health*, **33**, 33-40. (Japanese)