EFFECTS OF PERCEPTUAL-MOTOR ACTIVITY ON COGNITIVE ABILITY

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Abstract

The present study was undertaken, using children attending special classes for mentally retarded as subjects, in order to clarify the effects of physical activities on their cognitive abilities. All the subjects were tested and re-tested with two months of interval in motor ability, intelligence and discrimination ability of directions. The subjects in the experimental group (mean IQ by WISC, 60.0) were engaged with 45-minute long daily physical exercises during the experimental term, aiming at improvement of balancing and rhythmic abilities, combined with various ball-games, while those in the control group (mean IQ by WISC, 58.7) participated in the regular curriculum. As the result, the balancing and rhythmic abilities among the experimental group subjects were significantly improved, and hence the effect of prescribed exercises was recognized. The ability of left-right discrimination among the experimental subjects were found to be significantly larger in its improvement (left-right discrimination of body segments, P<0.01), while no significant differences were observed between the experimental and control groups in the amount of changes in intelligence, shown as IQ score improvements, though IQ scores were greater in the re-test in both groups.

Introduction

Several theories have been proposed on the effects of physical activities in the development of cognitive ability in young child. Piaget (1947), for example, insisted that abstractive and conceptual thinking of high level develops out of more concrete perceptual and physical themes (le schème). According to Hebb (1947), fundamental mediation process is formed through perceptual-motor experiences of the young child in his early stage of development. Such process, as he pointed out, becomes the foundation to the secondary learning. He then indicated that smooth intellectual development of higher level cannot be expected without thorough development of the mediation process. The theory on cognitive ability development then, has been considerably affected by Kephart (1964) who viewed the child's development as a combination of perceptual and behavioral worlds through corresponding perceptual and motor experiences, and symbolic and conceptual maneuver is only developed as a systematic accumulation of such experiences. For this reason, Kephart insisted, difficulty in learning may occur on a child who is exposed to education of abstractive matters, such as letters
and numbers, before firmly establishing fundamental perceptual-motor world. This was why he stressed the importance of physical activities including balancing, maintenance of posture and locomotive movements. Cratty (1969), on the other hand, less evaluated the theory of motor experience being the necessary foundation of intellectual development than those whose theories have been introduced above. He was thinking it necessary to have motor experiences heavily related to the intellectual elements, thus attempted to promote cognition of figures and letters and to teach arithmetics through learning games. A few other studies on the same line have been given as reported by Cratty and other investigators (1972), which resulted in stimulating attempts to promote cognitive development of the child by physical activities.

Review of Literature

Experiments to promote development of cognitive abilities, especially that of intelligence, by systematically providing physical activities for a certain period of time have been conducted by a few researchers in the U.S. using handicapped children or normal young children who have not developed such abilities yet on their development of cognitive abilities.

Oliver (1958), for example, compared a group of sub-normal boys (IQ: M=70.1, Range =57~86) who were exposed to a systematic program of progressive physical conditioning for ten weeks with boys in the control group of similar nature to whom regular physical education program was provided. He found a significantly greater improvement in motor and intellectual abilities in the experimental group than the control group. Corder (1966) likewise reported results of a study in which a group of mentally retarded boys (Age: 12~16 years, WISC IQ: 50~80) demonstrated a significant improvement in intellectual abilities after being exposed to a progressive and systematic program of physical education for four weeks, each week consisting of five sessions.

Then, McCormic and others (1968) studied the contribution of physical activities on reading ability of first grade slow-learners. According to their results, significant improvement in reading test results were obtained among those who received perceptual-motor training, while no changes in reading ability were found among those who received only regular physical education curriculum. Chasey and Wyrick (1970), on the contrary, reported no effects of physical activities aiming at promotion of physical development that were executed for mentally retarded children (IQ: 50~85) whose age varied between six and twelve years.

Positive results have been generally reported regarding the effects of physical activities provided for children whose development in cognitive abilities is deficient, whereas no significant contributions are found, more or less, when subjects were normal children. O'Corrner (1969), after comparing the contribution of six months long Kephart-type physical activities and traditional physical education program given for normal first graders, found a significantly greater improvement in motor ability test results among those who received the
former program than the latter, though such improvement in motor ability made no specific contribution to either perceptual performance or academic achievement. In the study made by McCormick and Schnorbrich (1971) in which three times a week of perceptual-motor training for seven months was exposed to Montessori pre-school children, no significant IQ improvement in comparison to control group was recognized. Four months of gymnastics and music training then, produced no influence on the general intelligence of the four year old, according to Leithwood and Fowler (1971).

**Purpose of the Study**

While attempts have been actively made in the U.S. to promote development of cognitive abilities of the young child by means of various forms of large muscle activities, practically no studies have been conducted in Japan. The primary objective of physical education program in the education of mentally retarded children in Japan, for example, has rather been placed upon the development of physical abilities alone. Even though practical application of actual life to school life, from the experimentalist's view, may have been observed in this case, little of the total body activities in the sense of physical education have been applied, and perhaps no considerations have been given to the relationship between physical activity and cognition. The purpose of this study, therefore, was to clarify whether a selected series of physical activities, the core consisting of balancing and rhythmic exercises combined with various ball-games, affect intellectual abilities and whether such physical activities promote ability of directional cognition which is considered to be highly related with respective exercise among the mentally retarded children. The balancing and rhythmic exercises were chosen because the mentally retarded are particularly inferior in these abilities to the normal children, and because motor abilities are considered to be reasonably related with intellectual abilities and academic achievement among them.

**Methodology**

The study was undertaken by using fifty-nine children whose age varied between seven and fourteen years, attending special classes for mentally retarded. The experimental group originally consisted of seventeen boys and eight girls, total of twenty-five, while the control group originally consisted of twenty boys and fourteen girls, total of thirty-four, though later the size of each group was lessened to a certain degree due to the fact a few of the subjects did not complete the post-experimental test. Upon administering Wechsler Intelligence Scale for Children (WISC), the full-score intellectual quotient (FIQ) scores ranged, for the experimental group, 36~95, and the control group, 36~98. The mean FIQ for the former was 60.0, and the latter, 58.7. As these subjects come from three different schools, due to procedural convenience, children from one school were assigned to be experimental group subjects and two schools, control group subjects.

All the subjects were first tested by intelligence test, motor ability test and left-right discrimination test in both hands. The subjects of the experimental group were then regularly
exposed to 45-minutes long daily physical activities as follows for two months:

(1) Balancing exercise: Walking on variety of balance beams, low and wide and tall
and narrow being examples, with certain conditions prescribed, such as striding over
some obstacles placed on the beam and throwing and catching balls.

(2) Rhythmic exercise: Variety of rhythmic movements, such as hopping and skipping,
requested while proceeding a routine process, indicated by circle, triangle and other
signs drawn on the ground.

(3) Exercise for directional cognition: Running, jumping and moving certain portion
of the body to specific direction upon receiving various signals.

(4) Various ball-games: Ball-games of different kinds that the subjects enjoyed to play,
distributed in the total exercise session upon interest of the subjects, for prevention
of dullness.

The control group took regular class program during the time period when the experi-
mental group undertook the prescribed exercises. Motor ability, intelligence and left-right
discrimination tests were then administered again to both subject groups after two months
of experiments. The tests may be outlined as follows:

(1) Motor ability test: 25-meter dash, standing long jump, repetitious jump over obstacle,
single leg stand with closed eyes, single leg stand with eyes open and arms crossed
at the chest, rhythmic test in which hopping and skipping rhythms were taken by
hands and feet and its performance was rated by use of three level grading.

(2) Intelligence test: WISC.

(3) Left-right discrimination: Indication of direction (right or left) upon receiving verval
signals, pointing the direction or the part of the body by fingers, indication of direc-
tion upon receiving verbal signals, pointing the direction in the person painted, direction
in the space by moving oneself quickly upon receiving verval signals indicated.

**Results**

Although the quality of test scores between the two groups was hoped to be even, prior
to giving prescribed exercise program, rhythmic and balancing test scores showed considerable
differences, experimental group being superior. The first test results, naturally, were con-
siderably inferior to that of normal children, in general, though a few subjects demonstrated
quite comparable scores in certain test items to the normal.

Amount of changes in the recorded results between the test and re-test, which were
statistically examined for significance, are exhibited in Tables 1~3. In these tables, regardless
to the unit, + mark indicates positive improvement of performance and −, decrease in ability.
As presented in Table 1, no significant increases in 25-meter dash, standing long jump and
repetitious jumping abilities in both groups were found. Balancing and rhythmic abilities were
significantly improved in the experimental group, while in the control group, the only signi-
ficant improvement found was rhythmic abilities among girls. This outcome suggests
that the physical activities that were applied in this study were efficient enough for develop-
### Table 1. Comparison of Amount of Changes in Motor Ability Test Results before and after Experimental Activities

<table>
<thead>
<tr>
<th>Test item</th>
<th>25m dash (sec)</th>
<th>Standing long jump (cm)</th>
<th>Repetitive jump (sec)</th>
<th>Single leg standing with eyes open/ closed (points)</th>
<th>Single leg standing on a bar (right) (sec)</th>
<th>Single leg standing on a bar (left) (sec)</th>
<th>Rhythmic test (points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>-0.2</td>
<td>+1.8</td>
<td>-0.1</td>
<td>+0.4</td>
<td>+28.1**</td>
<td>+25.1</td>
<td>+1.6*</td>
</tr>
<tr>
<td>Control Group</td>
<td>-0.4</td>
<td>-7.6</td>
<td>+1.0</td>
<td>0</td>
<td>1.9</td>
<td>1.1</td>
<td>+0.3</td>
</tr>
<tr>
<td>Difference</td>
<td>0.2</td>
<td>9.4</td>
<td>1.1</td>
<td>0.4*</td>
<td>26.2</td>
<td>24.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Experimental Group</td>
<td>-0.3</td>
<td>+0.2</td>
<td>-3.3</td>
<td>+0.7*</td>
<td>-1.3</td>
<td>+2.0</td>
<td>+0.7*</td>
</tr>
<tr>
<td>Control Group</td>
<td>-0.3</td>
<td>-9.4</td>
<td>+0.7</td>
<td>-0.3</td>
<td>+1.3</td>
<td>-0.2</td>
<td>+1.3*</td>
</tr>
<tr>
<td>Difference</td>
<td>0</td>
<td>9.6</td>
<td>4.0*</td>
<td>1.0*</td>
<td>2.6</td>
<td>2.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

* P<0.05  ** P<0.01

### Table 2. Comparison of Amount of Changes in Intelligence Test (WISC) Results

<table>
<thead>
<tr>
<th>Item</th>
<th>Verbal Test</th>
<th>Performance Test</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Experimental Group</td>
<td>0.4</td>
<td>-0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Control Group</td>
<td>0.4</td>
<td>1.4**</td>
<td>-0.2</td>
</tr>
<tr>
<td>Difference</td>
<td>0</td>
<td>2.0**</td>
<td>0.6</td>
</tr>
</tbody>
</table>


### Table 3. Comparison of Amount of Changes in Discrimination Test Results

<table>
<thead>
<tr>
<th>Item</th>
<th>Pictures</th>
<th>Body Segments</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>0.3</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Control Group</td>
<td>0.1</td>
<td>-0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Difference</td>
<td>0.2</td>
<td>1.1**</td>
<td>0.3</td>
</tr>
</tbody>
</table>
ment of balancing and rhythmic abilities in the kind of subjects used within the study. When the amounts of improvement among items studied were statistically examined, rhythmic abilities in girls showed a significantly greater improvement for experimental group than that of control group. The improvement ratio in repetitious jumping in the experimental group was smaller than that in the control group.

As presented in Table 2, no significant differences in improvement ratio in intelligence tests between the two groups were found, though, in general, slightly greater improvement was observed among the experimental group subjects than the other. More specifically, significant improvement was found among the experimental subjects in five sub-tests, i.e., verbal IQ, 2.3, performance IQ, 4.8 and total IQ, 3.7; while similar improvement was also observed among the control subjects. The differences in the amount of improvement between the two were; verbal IQ, 0.2, performance IQ, 1.4 and total IQ, 0.4. Then only items that showed significant differences in the amount of improvement were; comprehension in verbal test, control group being superior, and picture arrangement test, experimental group being superior.

The experimental group showed greater, though not significant, except cognitive ability of right and left sides of body segments (P<0.01), amount of improvement, as demonstrated in Table 3.

In general, positive attitude was observed among the subjects in taking the tests and results, especially in the case of experimental group, subjects seemed to have enjoyed participating in prescribed physical activities. In addition, according to the observation by the classroom teachers, the subjects improved activities in their daily behavior during the two-month long experimental period.

Discussion

Two different logical approaches may be made in understanding that properly provided physical activities would promote development of cognitive abilities. That perceptual-motor experiences are the basis for development of cognitive abilities is one way of explanation, while the other considers the motor experience as a positive stimulation to develop cognition. The latter is based on a view that every motor experience includes and/or can be made to include cognitive phase and therefore, the cognitive factors can be emphasized while children are engaged in physical activities. In the present study, the investigators, attempting to provide consideration for both viewpoints, included studies of effects of physical activities centered around balancing, rhythmic and coordination activities on intelligence and whether such physical activities may improve directional cognition.

The physical activities applied in this study were proved to promote balancing and rhythmic abilities, among variety of abilities aimed to be promoted, but were proved not to affect intellectual abilities significantly. Significant improvements in intelligence, tested by WISC, were seen in both experimental and control groups, perhaps due to experience effect of intelligence tests. In interpreting the above results, however, it should be noticed that the
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experimental group was superior in balancing and rhythmic abilities and hence, these two subject groups were not necessarily equal each other.

The possibility of improvement in the directional cognition by physical activities was suggested as the cognitive ability of right and left sides of body segments was significantly improved by experiment, besides those of picture and space were also improved, though statistically insignificant. The testing technique applied in this study, involving movement of body segments along with turning or locomotive movement, might not have been particularly effective in testing the ability to judge the sides of person drawn in pictures by symbolizing the direction or that of space by turning to different directions each time of test. For further study of this section, prescription of exercise for experiment should be searched more.

Then, whether the testing technique applied in this study for recording the development of perceptual-motor abilities, particularly intelligence test, is adequate or not remains unsolved.

The changes in behavioral patterns among the subjects while engaged in the prescribed exercise, though not objectively recorded during the present experiment, need to be carefully studied. In this study, it was felt that the subjects became more active, while similar trend has been pointed out by other investigators, too. Oliver (1958), for example, reported improvement in perseverance, cooperativeness and willingness in daily life among the subjects whom he gave prescribed exercise as a part of his experiment. McCormic and Schnorbich (1971) reported broader visual and auditory attention span among their subjects. Johnson and his co-workers (1968), found changes in self-concept towards desirable direction when their subjects who were emotionally disturbed, mentally retarded and brain damaged children, were engaged in twice a week of play-oriented neuromotor-perceptual training for six weeks. Okuyama (1969) likewise noticed more stable emotion and more efficient social adjustment among the physically sub-fit children after six months of training. Maloney and Charrette (1970) found that attention control training by use of walking board may become an opportunity of discrimination learning. These reports, besides two viewpoints introduced earlier, indicate the importance of another viewpoint based on the possible fact that physical activity activates non-intellectual factors which support cognitive abilities, such as attention control, willingness to face with assignments and self-control.

Any experimental studies that involve periodical physical activities for certain period of time in order to determine its effect cannot be free from possible influences of accumulative experiences pertinent to school and family life during the respective time span. The difficulty in equating the experimental and control groups was certainly unavoidable in the present study. The results obtained in this study, should be carefully interpreted taking considerations on respective limitations. (For conducting the study, Ministry of Education sub-sidized some part of the project in a form of scientific research grant.)

References

1) Chasey, W. C. and Wyrick, W., "Effect of a gross motor development program on form perception


