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original paper

Effectiveness of "Cognitive Movement Training" for Children with Mental Disabilities

Kimiyasu Hayakawa[1) 2)]

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Abstract: Purpose: The primary purpose of this study is to improve the health and ability to perform daily activities in children with mental disabilities, it is likely that similarly to individuals without such disability, many forms of physical training are required. Therefore, in this study, we used "cognitive movement training machines" with the expectation that they would allow children with mental disabilities who dislike exercise to have fun training, and analyzed the results to determine the effectiveness of the training program on improving their physical and mental well being.

Methods: We conducted a 3-month cognitive movement training program with 23 high-school age boys with mental disabilities attending a school for the disabled. The subjects had a range of disabilities, with many showing autistic tendencies and communication difficulties. The training sessions were provided once a week for 30 min for each child. We used a "sprint training machine", an "axle-motion power bike", an "ipsilateral hand-foot machine", and a "leg-hip extension machine".

Results: The body fat percentage of the subjects decreased and considerable improvement in exercise ability was observed. Improvements, some of which were significant, were seen in the 50m dash, 10m walk, 10m obstacle walk, and leg angle while attempting the splits. According to a questionnaire survey of the subjects' legal guardians, the behavior of the subjects was improved and their motivation to exercise was increased. The subjects' daily lives were observed to be improved from a mental and psychological standpoint.

Conclusion: Cognitive movement training was recognized as an effective training method improving physical, behavioral and psychological well being, and one which children with mental disabilities can continue safely and enjoyably.

Key words: Spiritual life, Quality of motion, Physical activity, Body fat, Ability for life

Introduction

Health problems accompanying obesity and lack of exercise are more prominent in individuals with mental disabilities than in those without such disabilities[2, 19, 25]. While the need for children with mental disabilities

1) Research Center for Total Life Health and Sports Sciences, The University of Tokyo
2) Department of Sports and Exercise Nutrition, School of Physical Education, Sendai University

to engage in physical exercise is recognized, there are a number of problems associated with putting measures into practice and many children do not like physical exercise. The physical education portion of the official curriculum guidelines issued by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) of Japan aims to increase children's physical strength and abilities through "various sports"[20]. In special needs schools, this is carried out through activities of walking, running, ball games, swimming and skiing among others; however, within the school curriculum, there are few examples of physical exercise training involving machines being used. Exercise is difficult for many of the children due to problems with posture, such as "walking on tiptoes", "retroflexion", and "hyperextension of the neck"[17]. As a result, it is necessary to properly consider the abilities and disabilities of the participants when carrying out exercise activities[8) 10) 23)].

Lately, the effect of bodily exercise on brain activation has attracted attention. Studies by using the "cognitive movement training machines" developed by Kobayashi[14] have showed the success of such training among elderly individuals who are frail or have dementia[16) 31) 32)]. In addition, the results of using cognitive movement training by small numbers of subjects with mental disabilities have been reported[9) 30) 33)]. However, to date, there have been no reports of the use of "cognitive movement training machines" by a comparatively large group of subjects with mental disabilities.

Therefore, in this study, we examined the influence of using "cognitive movement training machines" on the mental and physical state, as well as on activities of daily living (ADL), by a comparatively large number of high-school aged boys with mental disabilities attending a school for the disabled (currently termed a special support school).

Methods

Subjects

The subjects of this study were 23 high-school age boys(age: 16.9 ± 0.8 yrs, height: 165.5 ± 6.2 cm, weight: 61.8 ± 12.7 kg, % fat: 17.7 ± 9.0 %) with mental disabilities who attended a prefectural school for the disabled (referred to as a special support school after 2007).

Many of the subjects had a noticeable tendency towards autism, had difficulties expressing greetings, and needed to be led by the hand when walking. Others could carry out some degree of conversation regarding everyday life and could perform normal daily activities.

We thoroughly explained the purpose of this study and a protocol to the school management and obtained approval to conduct the study, as well as the written consent of the legal guardian of each student who would participate in the training program. We also obtained the prior consent of the legal guardians for the announcement of this study's results. We carried out our protocol with due respect to the students' feelings and wishes regarding their participation. Each participant underwent 30 min of training once a week over the 3-month period between January and March 2007. This study was approved in Ethics Committee of Tokyo University.

Training Process

We used two kinds of "soft muscle training machines" developed for use by individuals with low physical strength. These machines called "Body Repair" are produced by Senoh Corporation, Japan and are used for training leg-hip extension and ipsilateral hand-foot movement. Thirty repetitions of the specific movement being trained were performed on each machine. The machines allow for the control of electrical resistance, and are newly developed muscle workout machines which can be used without strain. The goal was to produce training results with a light load through relatively easy motion, and subjects used both types of machine while seated. The motion on the leg-hip extension machine stretches the knees and lower back, while the ipsilateral hand-foot machine moves the arms and legs on the same side of the body simultaneously.

Furthermore, we introduced subjects to the use of a "sprint training machine" and an "axle-motion power bike" . The former machine has electronic controls, and the subject places both feet on the pedal arms with the axis of revolution set to horizontal. The pedals automatically move for a single stride. The user matches this movement and presses the pedals with appropriate timing. This machine was used in the cognitive movement training program for basic training of walking and running motions. The latter machine is different from a normal rigid bicycle ergometer. The pedals run on an elliptical track, and the handles are not fixed and can turn. The subject has to turn the handles towards the same side as the foot pedaling, thus producing ipsilateral movement. Both machines were used continuously for a target time of between 1 and 5 min.

Measurement of physical strength and stature, and ADL questionnaire survey

Height, weight and body fat percentage (Body Composition: Tanita Corp.) were measured as indicator of physical stature. Additional measurements were taken based on a new fitness test from MEXT covering the 10m walk, 10m obstacle course, 50m dash, and the hip joint angle while attempting the splits. A comparison between the pre- and post-intervention measurements results was made.

A questionnaire inquiring about changes in the daily activities of the subjects was completed by the legal guardian at the end of the 3-month period of training. Respondents answered the following questions using a 5-point scale (1=not at all, 5=very much): spirit of challenge, "Do you feel that your child's spirit of challenge has increased compared to before participation?" ; motivation to exercise, "Do you feel that your child's motivation to exercise has increased compared to before participation?" ; sleep behavior, "Do you feel that your child's sleeps have been better compared to before participation?" ; and tendency to become ill, "Do you feel that your child has been sick less often compared to before participation?" Space was also left for free comments.

Observation of movement

Motions which could not be quantified were observed and recorded by one of the authors (K.H.), and then compared between pre- and post-intervention.

Statistical Analysis

Values are presented as means ± standard deviation. Differences were compared between pre- and post-intervention using Student's t-test and statistical significance was set at $p<0.05$. Data was analyzed using SPSS software, version 14.0 (SPSS Inc., Chicago, IL).

Results

Cognitive Movement Training Process

Individual differences were considered using the soft muscle workout machines for low strength individuals. The training was begun with a load ranging between 0-5 kg (fewer than 30 repetitions) for the subjects, and the weight was increased as they became accustomed to the training. It was ultimately increased to 5-18 kg by the end of the 3-month training period.

For the sprint training machine, speed and stride width were increased slightly with proper consideration of the subject's condition according to the trainer's judgment. The axle movement speed was started at "slow" (30 cm/s) or "medium" (40 cm/s), and the stride length was started from 35-55 cm. At the end of the 3-month training period, speed levels was increased to "medium" and "high" (50 cm/s), and stride width was increased to 40-65 cm (maximum width).

The load on the axle-motion power bike was set so that the pedals moved naturally when the subject's body weight was applied. At first, the subjects pedaled slowly and were then encouraged to pedal more rhythmically as they became accustomed to the motion. At first, the elliptical motion of the pedals was difficult for the subjects to master, but they gradually improved. The main purpose of using this machine is to move the ipsilateral leg and arm simultaneously. Half of subjects reached an exercise level comparable with that of individuals without disability.

Change in physical strength and stature

Physical strength measurements taken at the end of the 3-month training period revealed some significant changes. A significant improvement was observed in the 50m dash (n=15), from a pre-intervention time of 22.3 ± 12.5 s to a post-intervention time of 17.1 ± 9.5 s ($p<0.05$; Figure 1). Significant reductions were seen in the mean 10m walk time (n=16; 8.3 ± 3.1 s to 6.2 ± 1.8 s; $p<0.01$; Figure 2) and the 10m obstacle course walk

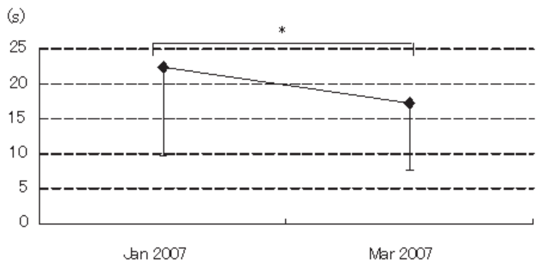

Figure 1 Change in the pre- and post-intervention times for the 50m dash in high school-age boys (n=15) following the 3-month exercise program. *: $p<0.05$.

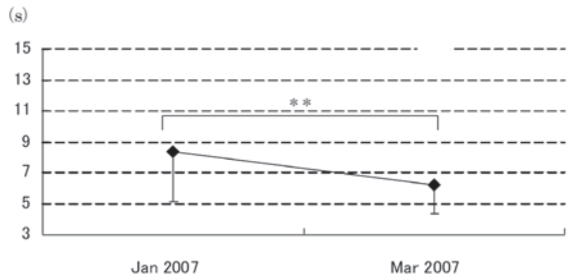

Figure 2 Change in the pre- and post-intervention times for the 10m walk in high school-age boys (n=16). **: $p<0.01$.

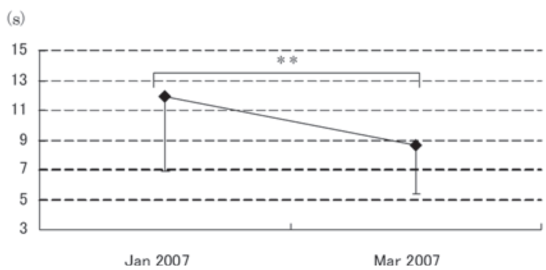

Figure 3 Change in the pre- and post-intervention times for the 10m obstacle course time in high school-age boys (n=16). **: $p<0.01$.

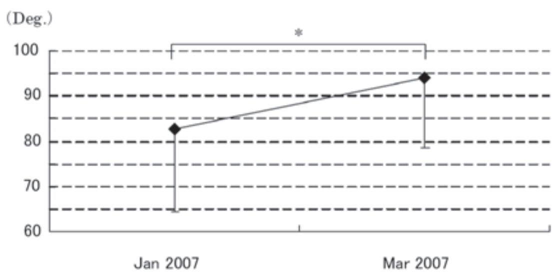

Figure 4 Change in the pre- and post-intervention measurements of degrees for the leg angle when doing the splits in high school-age boys (n=14). *: $p<0.05$.

(12.0 ± 5.0 s to 8.6 ± 3.3 s; n=16; $p<0.05$; Figure 3). Measurement of the hip joint angle while attempting the splits showed a significant increase from 82.8 ± 18.3 degrees to 94 ± 15.5 degrees (n=14; $p<0.05$; Figure 4).

The change in mean 50m dash values by high-school year is shown in Figure 5. The 10^{th} graders became significantly faster by the 3-month training (n=6; $p<0.05$). Although the 11^{th} graders (n=7) did not become significantly faster, some improvement was seen. As there were only two 12^{th} graders, our sample was too small to make any statement regarding significance. Comparing our results to the national average for regular high schools, there was a marked difference; our subjects had an extremely low running ability.

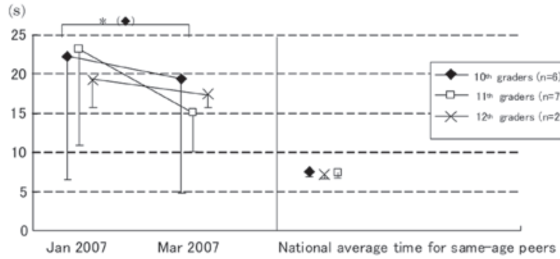

Figure 5 Change in the pre- and post-intervention times for the 50m dash in 10th, 11th and 12th graders, and in comparison with national average time for same-age peers. *: $p<0.05$.

The change in 10m obstacle course times by high-school year is shown in Figure 6. The 10^{th} graders showed a significant reduction in time by the 3-month training ($p<0.01$). A reduction in time, although not significant, was seen in the 11^{th} and 12^{th} graders. As there is no national average data available from regular high schools, we compared our subjects' values with the national average for healthy seniors aged 65-69 years. Our subjects had a lower ability to manage the obstacles compared to the seniors.

Looking at some individual cases, over the 3-month training period, Boy A's weight hardly changed (85.9 kg to 85.6 kg), although his body fat percentage was decreased markedly (40.4% to 32.3 %). In Boy B's attempts at the splits, he was only able to reach a 52-degree angle at first, which was improved markedly to 85 degrees at post-intervention. For Boy C, his time has been markedly improved in the 50m dash, 10m walk and 10m obstacle course by the 3-month training, decreasing from 41.3 s to 13.0 s, from 12.9 s to 5.5 s, and from 20.7 s to 6.2 s, respectively.

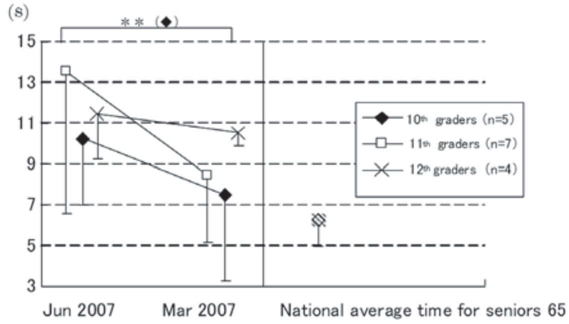

Figure 6 Change in the pre- and post-intervention times for the 10m obstacle course in 10th, 11th and 12th graders, and in comparison with national average time for seniors aged 65-69 years.
**: $p<0.01$.

At the beginning of the study, one student was not able to run, due to his weight, lack of interest, and refusal to run. However, after the training process, he was able to run intermittently for 50 m. Another student had to have the machine set to 0 kg for his back muscles and had difficulties in muscle strength at the beginning of intervention. However, at the end of the training program, he was able to lift 7 kg.

Questionnaire survey results

We conducted a questionnaire survey of the legal guardians of the elementary, middle, and high school students who participated in the program. Compared to before their participation, all respondents reported an "improvement/progress"

Figure 7-a Spirit of challenge

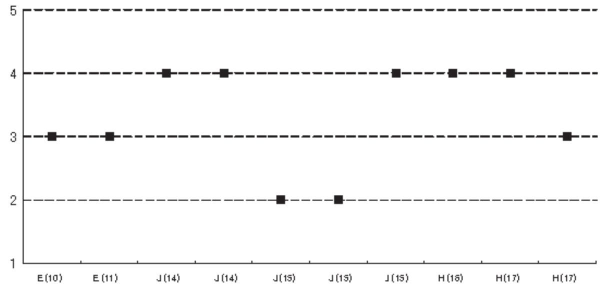

Figure 7-b Motivation to exercise

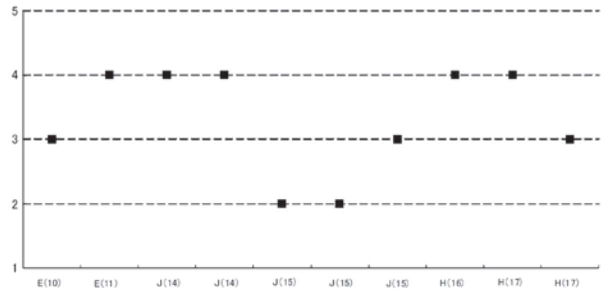

Figure 7-c Sleep behavior

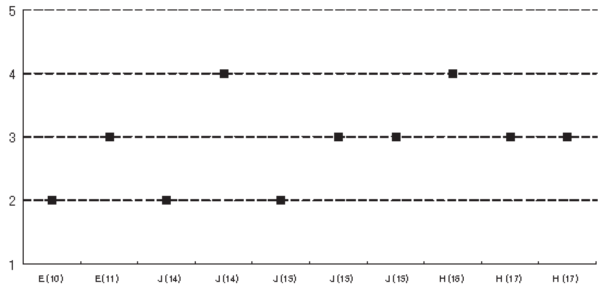

Figure 7-d Tendency to become ill

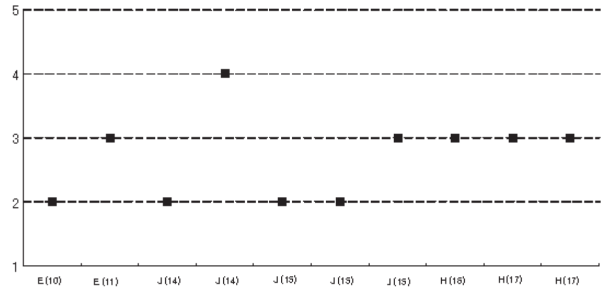

Figure 7 Change in 10- to 17-year-olds reported on a 5-point scale (1=not at all ～ 5=very much) by their legal guardians at the end of the 3-month training period for (a) spirit of challenge, (b) motivation to exercise, (c) sleep behavior, and (d) tendency to become ill. H: High-school student (age in y), J: Junior-school student, E: Elementary-school student.

in their child at the end of the 3-month training period in the areas of “spirit of challenge” , “motivation to exercise” , “sleep behavior” , and “tendency to become ill” (Figure 7 a,b,c,d). To the question, “How was participating in the training?”, some of the students clearly expressed that it was fun. In addition, according to the comments by the legal guardians, they felt the program was beneficial. Such comments included, “I am pleased that he could participate happily”, “He is looking forward to each training session. His daily behavior is gradually becoming more active” and “His bowel movements have been improved.”

Observation of movements

The observation records made by KH are shown in Table 1 . At the beginning of the program, signs of unease were seen among the subjects, although signs of curiosity

[In first month]
-There is a large difference in comprehension of the trainers' instructions
-There are those who cannot use the machine well
-Disregarding the difference in ability to use the machines, many of the people seem like they are having fun during the machine training
-During training, there were those who expressed a freeing joy. They spoke happily, and moved animatedly
[At the end of the 3-month period]
-They started to train and to speak spontaneously. Their words while training are becoming clearer.
-Their physical movements have improved.
-Even the students who were afraid at first are moving the machine better and better.
-Their motivation to participate in the training has increased.

Table 1 Example of observation records of the subject's behavior and response to physical training about the training machine and hints that it looked fun were also observed. As the training progressed, all the subjects showed improvement in physical movement and behavior, attendance was extremely good, and there were signs that the training has become an important part of their weekly life.

Discussion

The possibility has been raised that individuals with mental disabilities, similarly to healthy ones, are subject to lifestyle and habit-based illnesses[24], and such individuals were reported early[8]. They can also experience diseases and have a mortality rate related to being bedridden[3], as well as have problems related to the association between ADL and mortality rate[5]. Furthermore, among those with mental disabilities, it was suggested that exercise has a preventive effect for lifestyle diseases[6]. Thus, efforts to improve their physical strength and ability to carry out ADL from a young age are desirable.

Exercise training among individuals without mental disabilities is carried out in many ways. However, it is often difficult to motivate them to do the exercises directly, and thus a re-examination of the physical training methods in use would be of benefit. Although depending on the degree of disability, few such individuals recognize that exercise is good for their health, and they have a poor understanding of the science of health.

Most individuals without disability find physical training dull or tedious intermittently, but continue exercising because they have a clear awareness and comprehension of health. However, since most individuals with mental disabilities do not have a good grasp in this area, it is important to instill a sense of fun into any exercise program in order to promote continuity. Therefore, ensuring fun, safety, and continuity are more important factors to consider in their exercise programs.

The "cognitive movement training machines" have been previously used with either non-disabled or frail elderly subjects. With these subjects, the effectiveness of such aspects as fun, safety, continuity, and performance enhancement was demonstrated. In addition, the effectiveness of such physical training has been recognized with small numbers of children with mental disabilities at the University of Tokyo. In the present study, we performed the exercise training with larger numbers of children within a special support school to examine the validity of its use.

The main purpose behind using the "cognitive movement training machines" is to promote compound movement, and activation of the brain and motor neurons is expected. The actions produced using these machines are neither a repetition of a simple movement nor muscle strength training of a single joint. A top track-and-field athlete has trained using this machine, as well as older individuals among the general public. They became stronger in important movements and showed improvement in running, ADL, and exercise movements. Kobayashi[15] asserted his interpretation that "the nervous system relating to exercise is the general circuit that links the brain, the spinal cord, and the muscles" . In other words, it is likely that cognitive movement training promotes improvements in these areas.

In this study for children with mental disabilities, we aimed at advanced safety and continuity of the program. The improvement of physical exercise balance, strengthening of muscles, and activation of the parts of the brain which control the motor neurons, and ultimately a positive change in cognitive state, were expected. All of these expectations were fulfilled to some degree. A legal guardian commented, "he is looking forward to the training each time". The subjects themselves also expressed a wish for long-term continuous training when the study was completed.

In the measurements of physical strength, some subjects did not show improvement which could be quantified numerically. However, we observed that nearly all subjects showed clear improvements in strength and exercise ability. When the measurements were taken, hardly any of the subjects showed any competitive instinct or any feelings toward strong exertion, and this should be considered. For example, one subject's moods were stabilized through the continuing training and movements were calmed, while another subject experienced an increase in his desire to make quick movements through the training process. As some difficulties in measurement and evaluation were pointed out in a preceding study[13], many factors must be considered for the evaluation of physical strength in children with mental disabilities.

In the questionnaire given to the legal guardians, all respondents reported that their child experienced the following improvements by the end of the study: (1) increased spirit of challenge; (2) improved motivation to exercise; (3) improved sleep; and (4) an almost complete reduction in the incidence of illness. In other words, through the physical training regimen conducted in this study, the subjects improved in areas such as health, exercise ability, and the ability to carry out daily tasks. Moreover, subjects whose body fat percentage decreased significantly are likely to gain some protection against lifestyle-related diseases.

Autism has as one of its characteristics a decreased sense of cooperation and difficulty in interpersonal relations. It has been reported that a provision of much stimulation of the sense is effective to deepen the bonds between those with autism and their parents[27]. Additionally, Kalmanson[12] points out the importance of interpersonal relations in the learning process. Also, there are reports that interpersonal relations in individuals with severely mental disabilities have led to improvement in cognitive abilities[22]. In the 3-month training, the mental and psychological state of our subjects was improved using cognitive movement training, and the training was completed without a single accident or injury. It is also likely that appropriate support provided by the trainers is an important factor.

Dealing adequately with the senses and physical exercise is known to improve the behavior of children[1], and it is also reported that aerobic exercise (such as exercising to music) decreases self-stimulating motions (e.g., rocking behavior in individuals with autism)[26]. The physical and mental state is closely related to the proper workings of the nervous system[28], and it is reported that adequate stimulation of the senses is necessary to better support the physical and mental condition[4]. It is important that in accordance with these findings, cognitive movement training was shown to increase motivation and improve behavior as well as complex physical actions.

It is generally difficult for children with mental disabilities to understand health science and therefore it is likely that they would not wish to continue physical training unless it is fun for them. As a result, the first stage of the training is very important, the characteristics of which are that (1) the movement is fun, (2) the movement proceeds step-by-step, and (3) the movement builds motivation. The training carried out in this study fulfilled all of these conditions.

The subjects of this study were high-school boys. However, a small number of junior high-school students (3 boys, 1 girl) and elementary-school students (1 boy, 2 girls) with mental disabilities also participated in the training and evaluation. Both the junior high and elementary-school students had a reduction in time taken in the 50m dash and the elementary-school students had a reduction in body fat percentage. In the future, we plan to include test subjects from all grades in the training program in order to determine the effects of training by age.

Efforts to increase the abilities of individuals with mental disabilities in daily life in society are, of late, not limited to special facilities, but are also occurring within local communities[11]. A suitable training program for use in the community with those with mental disabilities considering their needs is desired[21]. Currently, in Kashiwa city, Chiba prefecture, Japan, a "cognitive movement training machine" has been introduced into a small training room (around 33m^2) at 8 local training gyms in the city where both the elderly and individuals with mental disabilities can train.

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