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Effect of Complex Training Program on Physical Fitness, Derivatives Reactive Oxygen Metabolite and Biological Antioxidant Potential Levels of Adolescents with Intellectual Disabilities

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Abstract

Aim: The purpose of this study was to examine the effects of complex exercise program on physical fitness, derivatives reactive oxygen metabolite (d-ROM) and biological antioxidant potential (BAP) levels of adolescents with intellectual disabilities, and to sugesst exercise programs to promote the health and physical development of such adolescents.
Methods: Sixteen students with intellectual disabilities were divided into 2 groups (Age: 13.37 ± 2.36 yrs, Height: 155.63 ± 9.72 cm, Weight: 63.24 ± 11.25 kg); exercise group (n=8), control group (n=8). The exercise group performed the complex exercise program 60 minutes a day, 3 times a week over a 12-week period. Then, the control group maintained their activities of daily living. Before and after the completion of the training programm, and physical fitness were measured and blood samples were assessed.
Results: The results of the study indicate that the 12-weeks complex exercise program increased significantly health- and skill-related. Furthermore, the d-ROM levels decreased more significantly in the exercise group than in the control group, and the BAP levels decreased after completion of the exercise program in the exercise group.
Conclusion: This study proved that the complex exercise program improved physical fitness, and reduced the d-ROM levels of the adolescents with intellectual disabilities. Therefore, it may enhance the health and physical development of adolescents with intellectual disabilities.

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Introduction

The social interest in people with disabilities has increasingly become an interest in welfare in today's society. In particular, adolescents with intellectual disabilities are restricted to their personal environment because their limited health- and growth-related physical activities. Therefore, they need more social concern.

People with intellectual disabilities have lower-than-average intellectual levels, and in particular, adolescents with intellectual disabilities have higher risks for cardiovascular disease and obesity that lead to type 2 diabetes mellitus via hypoactivity [1,2]. Compared with people without intellectual disabilities, they have slower walking speed because of their inability to control balance, coordination well [3], and perform physical activities efficiently with their weakened muscular strength, endurance, agility, and motor reaction [4].

Furthermore, people with intellectual disabilities tend to have high levels of reactive oxygen species (ROS) due to hypoactivity. More than 95% of ingested oxygen in the human body is combined with electrons produced from the energy metabolism of cells and reduced to water, but 2–3% of oxygen is reduced incompletely and generates free radicals [5,6]. Excessive physical activity causes formation of free radicals that leads to increases in oxidative stress and, finally, to negative effects [7, 8]. However, the human body deals with ROS through its antioxidant capacity, which can be increased by regular physical activity [9,10].

Adolescents with intellectual disabilities lack physical activity, which not only inconvenience daily life but also confers potential health risks with the reduced basic physical fitness. Therefore, it is important for such adolescents to work out regularly to improve their performance in activities in daily life and general health.

Generally, regular aerobic exercise has positive effects on body composition; similarly, resistance exercise also improves body composition by improving oxidative energy metabolic capability [11,6]. Advanced research studies on exercise, which investigated the effects of aerobic exercise on ROS levels and antioxidant capacity [12-14] and the effects of resistance exercise on oxidative stress levels and antioxidant capacity [15-17], demonstrated the positive effects of aerobic and anaerobic exercises on ROS levels and antioxidant capacity. However, the subjects of these studies were people without disabilities, and data from research studies on the effects of regular exercise on ROS levels and antioxidant capacity in adolescents with intellectual disabilities are not sufficient to be conclusive.

When designing an exercise program for adolescents with intellectual disabilities, findings from studies on the effects of regular exercise on body composition, physical fitness, oxidative stress levels, and antioxidant capacity should be considered. Adolescents with intellectual disabilities have weakened body coordination and movement ability as results from their inability to smoothly control muscle groups in each body part [18], and they are easily distracted, making their attention span short. Therefore, repeated general anaerobic exercise may be undesirable.

A new exercise program should be developed for adolescents with intellectual disabilities that could enhance their body balance and that involves frequent changes in body movement to prevent them

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from being bored, with consideration of their features rather than just just repeating simple exercises.

Therefore, this study aimed to develop an exercise program for the health improvement and growth development of adolescents with intellectual disabilities by examining the effects of complex exercise program on physical fitness, derivatives reactive oxygen metabolite (d-ROM) level, and biological antioxidant potential (BAP) levels with consideration of the features of adolescents with intellectual disabilities.

Materials and Methods

Participants

Sixteen adolescents with intellectual disabilities between 10 and 16 years old who were from Incheon city participated in the study(Age: 13.37 ± 2.36, Height: 155.63 ± 9.72, Weight: 63.24 ± 11.25). The participants were judged to have class 1, 2, or 3 intellectual disabilities, and could be rehabilitated in society and profession by education. This study was approved by the Department of Sports Sciences, University of Gachon, and complied with the requirements for human experimentation. After medical screening to rule out any conditions that might have precluded their participation, all the subjects provided written informed consent.

Study design

To examine the effects of complex exercise program on physical fitness, d-ROM and BAP levels, we conducted the participants in the exercise group to exercise 3 times per week for 12 weeks. The height, weight, were measured before using an automatic height/weight measurement system (BSM340, Biospace Co., Korea). Body composition and physical fitness were measured and blood samples were obtained before and after the completion of the exercise program.

Physical fitness

Health- and skill-related fitness were measured separately to assess fitness according to the effects of complex exercise program oriented toward balance reinforcement.

A basic fitness measurement system (THP2, Nurytec Co., Korea) was used to assess the health-related fitness and muscular strength (grip and back strengths), and measure muscular endurance (sit-up) and flexibility (sit and reach). To measure grip strength, the participants were trained to squeeze a dynamometer as hard as they could; measurement was performed twice for each hand, recording the higher value. In case of back strength, they were trained to pull utmost only with waist force while holding bars, with their backs straightened; measurement was performed twice, recording the higher value. For the sit-up measurements, beginning with a lying position, the participants were trained to lift their upper body up to the angle of a sensor, holding the position for 1 minute to allow the sensor to record the movement and then the total number of sit-ups made. In the sit-and-reach measurement, the subject stretched the upper body and hands forward, seating with the feet stretched, soles fixed to the measurement stand, with one hand on the other hand. Measurement was performed twice, with the higher mark recorded.

Hexagon agility and lower-quarter Y-balance tests were conducted to assess skill-related fitness. The hexagon agility test is the usual method of measuring quickness by measuring visual reaction, timing, and rate of physical reaction. The participants had sufficient practice of the exercises before the measurements were performed, and the highest record was adopted after two measurements in clockwise and counterclockwise directions.

In addition, the lower-quarter Y-balance test was used to test functional balance ability. After measuring the length of the legs, the maximum frontal, posterior, medial, and lateral distances were measured without losing balance, keeping the balance with the other foot. The higher mark was recorded after exercising with two feet alternately.

All the measurements were conducted after the participants had sufficient training on the exercises, considering the fact that adolescents with intellectual disabilities take longer time to learn the exercises than people without disabilities.

Analysis of d-ROM and BAP levels

Blood samples were collected 7 days before and 3 days after completion exercise program.The participants remained in a hunger state for 8 hours and were forbidden to engage in extreme sports until blood sampling from the fingertip capillary. The d-ROM and BAP tests were used to assess oxidative stress and antioxidant capacity levels [19, 20], using the International Scientific Community-certified oxidative stress analysis system. Measurement of the d-ROM levels were based on the ability of transition metals to catalyze, in the presence of peroxides, the formation of free radicals, which are trapped by an alchilamine. The d-ROM level was expressed as CARR U. It has been established that 1 CARR U corresponds to 0.08 mg/dL hydrogen peroxide [19, 21] From the manugacturer's instructions, the following classigication was made: very high oxidative stress, above 500 CARR U; high oxidative stress, from 401 to 500 CARR U; slight oxidative stress, from 321 to 340 CARR U; border-line, from 301 to 320 CARR U; and normal, from 250 to 300 CARR U. The BAP levels were expressed as μmol/L. The manufacturer's instruction shows the following classigication: optimum range, from 2,201 to 4,000 μmol/L; border line, from 2,001 to 2,200 μmol/L; moderate shortage from 1,801 to 2,000 μmol/L; shortage, from 1,601 to 1,800 μmol/L; severe shortage, from 1,401 to 1,600 μmol/L; and very severe shortage, less than 1,400 μmol/L.

Complex exercise program

In this study, the complex exercise program was conducted for 60 minutes per session, 3 times every 12-weeks. The total exercise program consists of warming up for 10 minutes, exercising for 40 minutes, and cooling down for 10 minutes. The participants mainly did stretching for warm-up and cool-down, and used tools such as an elastic band and swiss ball in exercises for balanced muscular strength development. In weeks 1 and 2, they were acquainted on the use of the tools within 7–9 degrees of intensity (very light to a little light) according to the ratings of perceived exertion (RPE); from weeks 3 to 12, the exercise intensity was increased from 1 or 2 sets to 2 or 3 sets. TheraBand elastic bands (Hygenic Corp., Akron, OH, USA) were used in the resistance exercises. The exercise intensity was set between 11 and 15 on the Bog scale, using yellow bands (0.5–1.3 kg) initially and gradually increasing to red (0.7–1.8 kg). Either a 45- or 55-cm diameter swiss ball was used, depending on the height of the subject. The components of the exercise program are detailed in Table 1. In this study, a trainer assisted the participants, considering that they had intellectual disabilities and were not used to the exercises.

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Variable	1–2 weeks	3–7 weeks	8–12 weeks
Warm-up	**Stretching** neck, shoulder, arm, wrist, leg, ankle, etc. for 10 min, RPE7-9		
Complex exercise	**Conditioning** **40 min, RPE7-9**	**elastic-band** arm curl, triceps extension, lateral raise, shoulder press, and chest press, each, 10–15 repetitions, 1 or 2 sets, RPE 11–13 intensity, rest for 1 min **swiss ball** back extension, hip bridge, squat, twist lunge, leg curl, and crunch; 10 repetitions, 1 of 2 sets, RPE 11–13 intensity, rest for 1 min	**elastic-band** crunch, back extension, hip flexion, hip extension, leg extension, and leg curl; each, 10-15 repetitions, 2 or 3 sets, RPE 13–15 intensity, rest for 1 min **swiss ball** bear walking, push-up, dumbbell press, shoulder press, dumbbell biceps curl, and one-hand triceps extension; 10 repetitions, 2 or 3 sets, RPE 10–12 intensity, RPE 13–15 intensity, rest for 1 min
Cool-down	**Stretching** neck, shoulder, arm, wrist, leg, ankle, etc. for 10 min, RPE7-9		

Table 1: The complex exercise program.

Statistical analysis

A statistical analysis was performed using the SPSS ver. 21.0 statistical program, and mean and standard deviations were calculated as descriptive statistics. An independent t test was performed to compare the 2 groups, and a paired t test was used to compare the changes between the before (0-week) and after (12-weeks). Statistical significance was set at $\alpha = .05$.

Results

Changes in physical fitness after 12-weeks complex exercise program

Health- and skill-related fitness were measured to evaluate the fitness changes after 12-weeks complex exercise program (Table 2 and 3).

Among the health-related fitness factors, right-left grip strength, back strength, muscular endurance, and flexibility were significantly increased after 12-weeks ($p < .05$) (Table 2). In the control group, back strength significantly decreased after 12-weeks ($p < .05$). In particular, back strength more significantly increased in the exercise group than in the control group ($p = .070$).

	Exercise Group (n = 8)		Control Group (n = 8)	
Variable	Before	After	Before	After
Right grip strength (kg)	13.52 ± 8.26	16.12 ± 7.32*	14.29 ± 9.38	15.011 ± 9.46
Left grip strength (kg)	12.61 ± 8.13	15.22 ± 8.86*	13.94 ± 8.15	14.12 ± 7.13
Back strength (kg)	22.47 ± 12.14	26.90 ± 13.91*	21.89 ± 13.21	17.77 ± 14.15*
Sit-up (count)	8.43 ± 6.51	11.12 ± 7.66*	9.27 ± 8.62	10.61 ± 7.77
Sit and reach (cm)	−2.38 ± 6.26	3.22 ± 5.87*	-1.72 ± 4.25	1.12 ± 7.23

Table 2. The changes in health fitness after 12-weeks exercise program

The data are presented as mean ± SD values.
*Significant ($p < .05$) difference between the baseline and 12-week periods.

	Exercise Group (n = 8)		Control Group (n = 8)	
Variable	Before	After	Before	After
Right-turn hexagon agility test (sec)	31.09 ± 17.53	22.67 ± 12.12	29.47 ± 15.63	28.69 ±16.23
Left-turn hexagon agility test (sec)	33.58 ± 24.46	22.32 ± 21.97	21.88 ± 8.89	21.16 ± 9.68
Right-foot Lower-quarter Y-balance test (sec)	34.04 ± 10.07	43.26 ± 9.28*	35.79 ± 9.96	34.41 ± 10.17
Left-foot Lower-quarter Y-balance test (sec)	31.21 ± 8.41	41.59 ± 9.89*	38.39 ± 10.62	38.98 ± 11.26

Table 4: The changes in skill fitness after 12-weeks exercise program.

The data are presented as mean ± SD values.
*Significant ($p < .05$) difference between the baseline and 12-week periods.

The changes in skill-related fitness between before and after the exercise program are shown in Table 4. Among the skill-related fitness factors, in the left-right turn hexagon agility test, no significant differences were observed between the 2 groups, and between the baseline and 12-week periods. In addition, the right-left foot lower-quarter Y-balance test results showed a significant difference between before and after the 12-week period in the exercise group ($p < .05$). In the right foot lower-quarter Y-balance test, the changes after the completion of the exercise program in the exercise group were significant increases from the baseline values ($p = .092$).

	Exercise Group (n = 8)		Control Group (n = 8)	
Variables	Before	After	Before	After
d-ROM (CARR. U.)	316.73 ±34.32	273.21 ±31.62*†	323.15±39.26	328.94 ±35.14
BAP (μmol/L)	2118.55 ±349.32	2311.71 ±452.13	2163.42 ±301.39	2236.23± 482.44

The data are presented as mean ± SD values.

*Significant ($p < .05$) difference between the baseline and 12-week periods.
†Significant ($p < .05$) difference between the groups.

Changes in d-ROM and BAP levels after 12-weeks complex exercise program

The changes in *d-ROM* and BAP levles after 12-weeks complex exercise program were detailed in Table 4. The d-ROM levels were significantly increased after 12-weeks, and decreased more significantly in the exercise group than in the control group (respectively, $p < .05$). The BAP levels increased after completion of the exercise program in the exercise group($p < .05$). These results mean that 12-weeks complex exercise program had positive effects on oxidative stress and antioxidant capacity.

Discussion

This study examined the effects of complex exercise program on physical fitness and d-ROM and BAP Levels in adolescents with intellectual disabilities.

People with intellectual disabilities have more difficulty performing intense physical activities without faltering than people without disabilities; thus, they have a greater tendency to be sedentary [22, 23]. The weakened body coordination and movement ability in adolescents with intellectual disabilities result from their inability to smoothly control muscle groups in each body part [18]. In this study, the fitness of the exercise group significantly improved after the 12-weeks complex exercise program in terms of right-left grip strength, back strength, muscular endurance, and flexibility. In particular, back strength more significantly increased in the exercise group than in the control group. This result indicates that the combined exercise program conducted in this study induced improvement in muscular strength by stimulating different kinds of muscle groups through swiss ball exercises and improvement in coordination through basketball and soccer ball exercises. Moreover, in this study, the right-left feet lower-quarter Y-balance test scores significantly increased in the exercise group after the 12-week period ($p > .05$), and the right-foot lower-quarter Y-balance test scores more significantly increased in the exercise group than in the control group after 12-weeks ($p = .092$). A decline in physical balance ability occurs owing to muscle weakness, proprioceptive function deficiency, and decrease in range of motion [3,19,21]. Physical balance is an essential element of daily life and an important single factor in deciding a movement strategy [24]. Many advanced studies reported that exercise using tools such as swiss balls and elastic bands stimulates proprioceptive function, improves movement sensation function, and effectively facilitates neuromuscular control [25-26]. The lower-quarter Y-balance test was used in this study to assess functional balance ability. The results of this study indicate that the combined exercise program may be considered as effective for improving functional balance ability, which seemed to have resulted from the positive effect that the use of tools such as swiss balls had on neuromuscular control.

Meanwhile, ROS has high reactivity and a short life compared with stable oxygen in the air; thus, it can facilitate the onset of many diseases by impairing biogenic substances during hypergenesis. When the oxydative stress levels exceeds that of the antioxidative system, it confers a negative effect on the human body [7,8]. However, advanced studies demonstrated that continuous physical activities increase adaptability that suppress accumulation of oxidative stress and decrease the active oxygen level in the blood by improving the oxidative defense of the body [27]. In the present study, the d-ROM levels in the exercise group significantly decreased after 12-weeks complex exercise program compared with that in the control group. This result is concurrent with those of advanced studies that reported improvement of cardiorespiratory function and oxydative stress levels in children who participated in an 8-weeks exercise program [28] and decreased oxidative stress in individuals who participated in regular exercise [29]. The previous studies reported that physical activities such as exercise could induce positive changes in active oxygen level [30, 31]. However, significant changes were not observed in the BAP levels after the 12-weeks complex exercise program in this study. This result differs from that of other studies that reported that regular exercise increased the activity of antioxidative enzymes and decreased oxidative stress. In this regard, Kim et al. [32] reported that antioxidant capacity is affected by exercise intensity and duration. Indeed, many advanced studies demonstrated that exercises with greater intensity induce greater activation of oxydative stress and antioxidant capacity. The complex exercise program adopted in this study was conducted at low intensity, considering that the adolescent participants had intellectual disabilities; despite this, the subjects had difficulty performing the exercises consistently per session. Therefore, the effect of a complex exercise program with more intense exercises on the antioxidant capacity in adolescents with intellectual disabilities needs to be further investigated [33].

Conclusion

This study demonstrated that complex exercise program effectively improved physical fitness, BAP levels, and reduced d-ROM levels of the adolescents with intellectual disabilities. Therefore, it may be useful for enhancing the health and physical development of adolescents with intellectual disabilities.

Conflict of interest

The authors declare that they have no conflict of interest.

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