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Original Research

The Effect of an Exercise Protocol Focused on the Combination of Strength and Proprioceptive Exercises on the Balance and Motor Performance in Boys with Intellectual Disability

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ABSTRACT

One of the main challenges of intellectually disability children is the high prevalence of gait and balance problems due to muscle weakness. The purpose of this research was to investigate the effect of an eight-week training protocol focused on the combination of strength and proprioceptive exercises on the balance and motor performance in boys with intellectual disability. 34 boys with intellectual disability aged 9 to 13 years were selected among the available people and randomly divided into two experimental (n=17) and control (n=17) groups. The experimental group performed selected sports exercises for eight weeks, and the control group did not participate in any regular exercise program. Static balance, functional balance, lower limb strength and gait speed were measured before and after the training period. The results showed that the combined protocol of strength and proprioceptive exercises had a significant effect on static and functional balance, gait speed and lower limb strength (P=0.001). No significant change was observed in the control group (P>0.05). Combined strength and proprioceptive exercises lead to the improvement of balance and movement performance of intellectually disability boys; Therefore, it is suggested to use this exercise protocol to improve the physical fitness factors of these patients.

Keywords: Intellectual disability, functional balance, gait speed, lower limb strength.

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INTRODUCTION

The term "intellectual disability" specifically refers to children who have defects in cognitive mechanisms and some compromising behaviors. Children with intellectual disability often go through the main stages of physical development, but due to the problems they have in cognitive and psycho-motor development, they have poor performance in perceptual-motor abilities and retrieving information from memory; In other words, in special activities that require decision-making, they have a weaker performance than normal people [1]. In developing countries, 4.6% of people under 18 years of age and in developed countries, 0.5 to 2.5% of people have intellectual disability. In general, this disability appears before adolescence and is more common in men [1]. Common defects and disorders in people with intellectual disability are: obesity, muscle weakness, low bone density and muscle strength, imbalance and postural malalignment, and vision, hearing and physical disability [2]. Intellectually disability people receive lower scores in perceptual-motor tests than normal people, and their balance is more unstable than healthy people due to the disruption in the integration of sensory-motor information [3]. In terms of education, intellectually disability people are divided into groups of slow learners (IQ 75 to 90), educable (IQ 50 to 70), trainable (IQ 50 to 25) and dependent or supportable (IQ lower than 25). Educable intellectually disability group have more problems than slow learners; But compared to the other two groups (trainable and supportable), they respond better to training [4]. In comparison with normal children of the same age, educable intellectually disability children have lower scores in physical strength, tolerance level, agility, running speed, reaction time and balance and they are between 2-4 years behind normal children in performing movement tasks [2].

It has been proven that static and dynamic balance is very important in a child's life. Since falling is a frequent event in people with intellectual disability, balance is more important in these children. Since mentally retarded children go through irregular and delayed stages of motor development, it seems necessary to include motor activities in their daily schedule. Considering that mental retardation cannot be cured, the main task for this category of patients is their rehabilitation and education [5, 6]. It has been said that the reported limitations in the mobility of people with intellectual disabilities are mostly due to the high prevalence of gait and balance problems in these people. On the other hand, considering that the ability to produce force and having sufficient strength in flexion and extension of the ankle and hip joints is necessary for proper balance strategies, it seems that balance and strength are two complementary factors [7].

Many researches have shown the importance of the role of exercise in improving balance, physical fitness and gait performance in children with mental disabilities. Ghasemi et al. (2016) in a research reported the positive effect of eight weeks of rebound therapy exercises on the static and dynamic balance of mentally retarded children [8]. In two separate studies, Daneshmandi et al. (2012) and Ahmadi et al. (2011) showed that the core stability training protocol improves the balance of mentally retarded people [9, 10]. Kong et al. (2019) confirmed the effect of Tai Chi exercises on improving physical fitness in mentally retarded children and adolescents [11]. Lee et al. (2016) showed that functional strength, balance and postural control improved significantly in the strength training group compared to the control group [12]. Jeng et al. (2017) in a review study showed that sports training has a positive effect on agility, power, reaction time, balance and speed in mentally retarded teenagers [13].

Despite this research, the researchers of the present study think that combining strength and proprioception exercises has more effects on balance and motor performance. Because, on the one hand, the effectiveness of various exercises on the strength and physical and motor fitness of mentally disabled people has been confirmed, and on the other hand, it has been proven that proprioception is one of the most important factors affecting balance performance and memory enhancement. In addition, walking, along with a physical function, is also known as a cognitive function and includes the integration of attention, planning, memory, and other motor, perceptual, and cognitive processes [14]. The delay in the motor development of the mentally retarded, which is associated with their weaker motor performance, and the lower IQ of these people, which affects their cognitive and motor performance [15], requires the use of exercises that, in addition to physical fitness factors, also emphasize the proprioception and strengthening their attention and concentration. In the review of previous research, no study was found that investigated the effect of combined strength and proprioceptive exercises on motor and balance performance of children with mental disabilities. Considering the effect of such exercises on strengthening memory and

concentration, the cheapness and availability of the tools of these exercises and the fact that a person can do them at home, the purpose of this research is to investigate the effect of combined strength and proprioceptive exercises on balance and motor performance, including static and dynamic balance, strength, and gait speed in intellectually disability children.

MATERIAL AND METHODS

Subjects

The method of this research was semi-experimental and pre-test-post-test with a control group. The statistical population of the research was made up of all the educable intellectually disabilities female students in Mashhad elementary schools with a calendar age of 9 to 13 years. Based on the obtained information, the available sample was the intellectually disabled students of Dr. Sajjadi's exceptional educational center in Mashhad. People with physical limitations or obvious behavioral disorders, as well as people with Down's syndrome, were excluded from the research due to the lower level of physical fitness compared to the mentally retarded. After additional explanations regarding the purpose of the exercise, a written consent was obtained from the children's parents for regular participation in the research. First, there were 40 intellectually disabled students available, and with the determination and examination of their medical records, 6 people were excluded from the research due to physical and physical disabilities, and among them, 34 students with an IQ between 50 to 70 (according to their medical records) were selected and randomly divided into two groups of 17 people, control and experimental. First, there were 40 intellectually disabled students available, and after examining their medical records, 6 people were excluded from the research due to severe physical and motor disabilities, and among them, 34 students with an IQ between 50 and 70 were selected and then randomly divided into two groups of 17 people, control and experimental. A written consent was obtained from the parents of all the children to participate regularly in the research.

Exercise protocol

The exercise protocol included a combination of strength and proprioceptive exercises as introduced by Kachori et al. (2016). The exercises of this protocol are presented and described in Table 1. This protocol was implemented for 8 weeks, three times a week, every other day, and each session lasted about an hour. This exercise program included 10 minutes of soft jogging and stretching to warm up and 50 minutes of the main exercise and the final 10 minutes to cool down. The exercises started with a low number and load and progressed gradually until the movements were performed with control. The intensity of the exercises was moderate for all the subjects, in the continuation of the sessions, people without fatigue did the exercises with more repetitions. The intensity of training increased every two weeks. To this end, the number of repetitions and sets changed over time; The exercises were performed as three sets of 15 repetitions in the first two weeks, three sets of 20 repetitions in the third and fourth weeks, four sets of 20 repetitions in the fifth and sixth weeks, and finally, five sets of 20 repetitions in the last two weeks [16]. During this period, the control group did not receive any intervention.

Equipment's and measurements

Stork balance test was used to evaluate static balance. Before starting the test, subjects were taught how to adopt the correct posture. Subjects were asked to stand on their dominant leg and place their toes on the knee of their dominant leg while placing their hands on their waist; Then, with the command of the examiner, lift the heel of the dominant foot and stand on your toes and maintain your balance without moving your feet or leaving your hands from your waist. If the heel of the supporting foot touches the floor, or the hands are separated from the waist, or the sole of the non-supporting foot is separated from the knee of the supporting leg, the effort is over and the time is recorded for him. During the test, the subject looked at the sign that was 4 meters away and in front of his face. Each subject had to perform this test 3 times with a 15 second rest interval and the best time was recorded as his score. The validity and reliability of this test are reported as 0.87 and 0.79, respectively [12].

Table 1- Exercises used in the combined protocol of strength and proprioception

Exercises	Description of exercises

1. Air squat	Air squat are simply squats don without additional weights, just using one's own body weight for resistance
2. Squat jumps	The participant should be standing, the movement beginning with knee flexion and extension up
3. Straight sit ups	Begin this exercise by lying flat on the ground with your legs straight. Place your hands behind your head. Pull your upper body all the way up to a sitting position, then slowly lower your upper body back down to the ground
4. Power sit up	The same exercise like straight sit ups but they knees bent, but not too much though
5. Flutter kicks	Start by lying flat on your back on a mat with your arms by your sides. Extend your legs. Make small rapid up and down scissor-like motions with your legs
6. Two-foot ankle hop	Start standing straight up. Using only your ankles (and calf muscles), hop (jumping) repeatedly in place
7. Single-foot side-to side ankle hop	Begin by standing on one leg next to one of the marks on the ground. Hop back and forth between the marks on the floor, landing on your right foot near the right mark and you left foot next to the left mark
8. Tuck jump with knees up	Start in standing position, slightly bending your knees. Hold your hands out at chest height. Lower your body quickly into a squat position, then explode upwards bringing your knees up towards your chest
9. Standing long jump	Standing behind a line marked on the ground with feet slightly apart. The subject attempts to jump as far as possible, landing on both feet without falling backwards
10. Double leg hops	Beginning by double legs hop forward by dropping your arms power and up, try to you jump for maximum height and distance for 3 or 4 jumps
11. Single leg hops	The same exercise but with one leg. Hop forward, jumping and landing with the same leg
12. Standing on one foot	Try to standing on one foot during 5-10s on foam lurking
13. Lateral jump with both feet	Start by standing on 2 legs with your hands on your waist or at your sides. Proceed to hop to the side while maintaining your balance and hop back to the starting position
14. Lateral jump with one foot	The same exercise but with one leg
15. Running up the stairs with one foot	Run up the stairs as fast as possible. Move your feet as quietly as possible from one stair to the next. Land and push off with the front half of your foot then lower your heel. Swing your arms and press off each step with your thighs
16. Running up the stairs with both feet	Hop-ups feet are shoulder width apart, attempt to jump with 2 legs at a same time one stair to the next

Timed up and go (TUG) test was used to evaluate functional balance. The subject was sitting on a chair without a handle and leaning on the back support of the chair while wearing regular clothes and shoes. At the command of the examiner, the subject would stand and walk the marked distance of three meters. After reaching the end, he goes around and returns and sits on the chair. The duration of this test was recorded in seconds as a person's score. The validity and reliability of this test are reported as 0.79 and 0.81, respectively [17].

To evaluate the gait speed of the subjects, the 50-step gait test was used with a validity of 0.80 and acceptable reliability. With the command of the examiner, the subject started walking at maximum speed along a 25-step path and then turned around at the end of the path and returned to the starting place of the test; The time the subject covered this distance was recorded as his record. A higher recorded score indicates a greater deficit in motor function and an increased risk of falling [18].

The chair sits up & down test with a validity of 0.78 and a reliability of 0.86 was used to evaluate the lower limbs strength. The subject was asked to put his hands on his shoulders and repeat the action of sitting and standing up from the chair 5 times without standing. The time of five repetitions performed by the subject was recorded in seconds; More time for this test indicates more weakness in muscle strength and coordination [18].

Data analysis

Descriptive statistics were used to describe the individual characteristics of the subjects. In order to compare the two experimental and control groups, the Covariance test was used with the pre-test factor as a covariate and the correlated t-test was used to compare the pre-test with the post-test in each group. The level of statistical significance was set at $p < 0.05$. All statistical analyses were performed using SPSS 21 software (SPSS Inc., Chicago, IL, USA).

RESULTS

Tables 2 and 3 show the individual characteristics and data distribution, respectively. According to Table 2, there were no differences between the individual characteristics of the two groups. Also, according to Table 3, the distribution of data in all variables was normal (P>0.05).

Table 2- The mean and standard deviation of individual characteristics of subjects

Variable	Group		Sig.
	Experimental (n=17)	Control (n=17)	
Age (years)	10.33±0.96	10.83±0.88	0.606
Height (m)	1.55±0.21	1.57±0.24	0.598
Weight (kg)	40.9±4.6	41.36±4.35	0.193
Lower limb length (cm)	75.5±7.78	76.1±7.37	0.113
BMI ($kg.m^{-2}$)	17.08±2.77	17.37±2.92	0.838

Table 3- Shapiro-Wilk test to evaluate data distribution

Variable	Group	Pre-test	Post-test
Static balance	Experimental	0.140	0.101
	Control	0.559	0.369
Functional balance	Experimental	0.116	0.115
	Control	0.937	0.989
Gait speed	Experimental	0.067	0.091
	Control	0.577	0.735
Lower limb strength	Experimental	0.238	0.194
	Control	0.269	0.366

* The significance level was considered as p<0.05

One-way covariance analysis between groups (Table 4) shows that by removing the effect of pre-test values, the observed changes in all 4 variables are statistically significant. Therefore, in the post-test, there is a significant difference between the groups and the effect size shows that the independent variable has the ability to explain the changes in the dependent variables. To check the intra-group differences (between pre-test and post-test) in each group, dependent t-test was used, the information of which is reported in Fig. 1.

Table 4- Comparison of variables in the post-test between groups

Variable	Group	Mean	F	df	Sig.	Effect size
Static balance	Experimental	13.04	0.904	1	0.001	0.87
	Control	10.9				
Functional balance	Experimental	7.1	0.625	1	0.001	0.56
	Control	7.8				
Gait speed	Experimental	20.8	4.87	1	0.001	0.94
	Control	21.3				
Lower limb strength	Experimental	10.15	11.66	1	0.001	0.89
	Control	12.2				

As Figure 1 shows, significant intra-group differences in static balance, functional balance, gait speed and lower limb strength are observed in the experimental group ($p<0.05$), but no significant change was observed in the control group; It can be concluded that there have been significant improvements in variables in the experimental group.

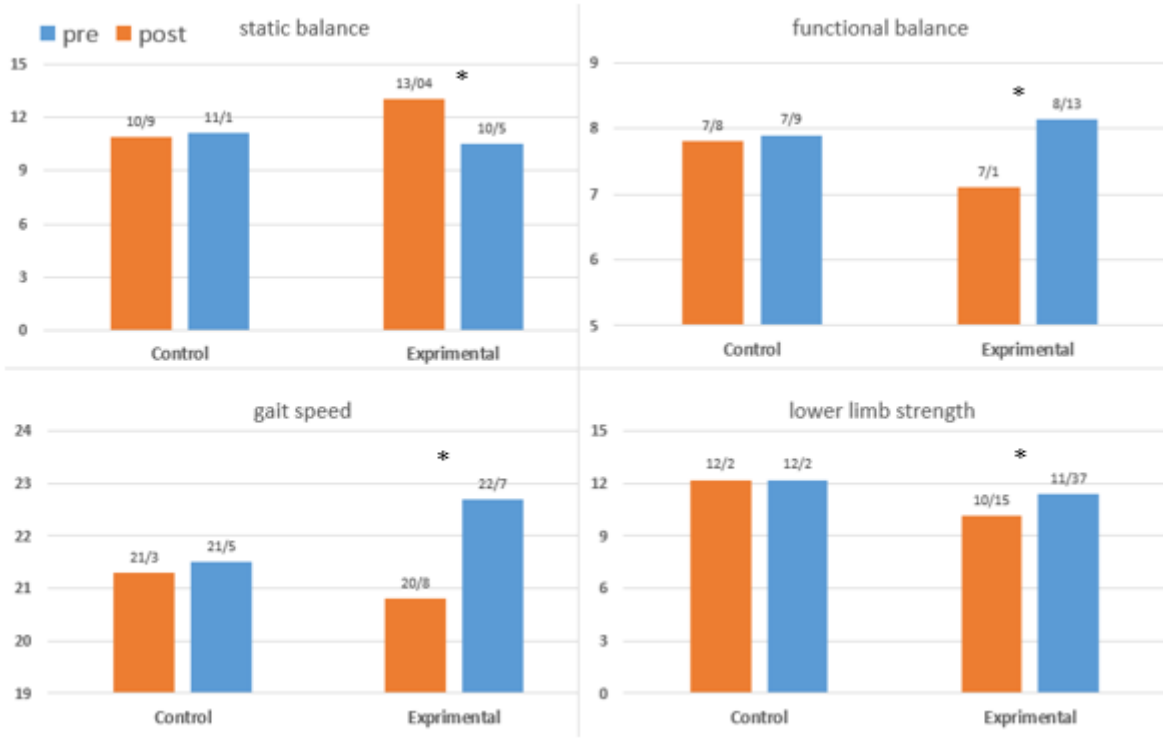

Fig. 1- Intragroup differences of variables in each group

DISCUSSION

The results of the present study showed that 8 weeks of combined strength and proprioceptive training has a significant effect on balance performance including static and functional balance in intellectually disabled students. The results of previous researches that studied the effect of exercise programs on the balance of mentally retarded children are in line with the findings of the present research. Researchers showed that balance exercises have a significant effect on static and dynamic balance in mentally retarded children [7, 19]. Hosseini et al. (2017) showed that postural and balance exercises have a significant effect on static balance and flexibility of children with intellectual disabilities [20]. In general, with different training programs, including strength, balance and aerobic training [21], trampoline training program [22], strength and balance training [23], core stability exercises [9, 10], selected correction-balance program [17], rebound therapy exercises [8], and balance and postural exercises [24], significant improvements have been reported in the balance of children with intellectual disabilities. Lee et al. (2016) showed that functional balance and postural control improved significantly in the strength training group compared to the control group [12].

The results of the present study showed that 8 weeks of combined strength and proprioceptive training has a significant effect on gait speed of intellectually disabled students. Giagazoglou et al. (2013) reported the positive effect of trampoline exercise on the motor performance of mentally retarded children [22]. Bahiraei et al (2019) showed that mentally retarded people have walking disorders, especially shorter step length, stride length and step width, and lower gait speed. These people also have kinetic and kinematic disorders, including a decrease in the production force of the ankle in the push-off phase, increased hip and knee flexion at stance phase, limitation of the range of motion of the knee and ankle at the heel contact and greater hip joint stiffness during the gait cycle. They suggested preventive measures to correct walking

disorders and reduce the complications caused by these disorders [25]. Jeng et al. (2017) in a review study showed that sports training has a positive effect on agility, power, reaction time, balance and speed in mentally retarded teenagers [13]. Zolghadr et al. (2019) showed that the selected corrective-balance program has a significant effect on the balance and walking speed of intellectually disabled students with developmental coordination disorder [18]. Kubilay et al. (2011) showed that the walking speed of mentally retarded children improved after eight weeks of balance and posture exercises [24]. Lee et al. (2014) showed that balance exercises increase the gait spatio-temporal function in young people with intellectual disability [26].

When moving, the force of gravity continuously pulls the body towards the ground and makes it out of balance. There are various and complex mechanisms that are involved in this process and keep the body in balance. The beginning of the activity of these mechanisms is when the body is in danger of falling. In this case, these mechanisms are activated to restore balance. These mechanisms include natural muscle contraction, preventing the stimulation of deep receptors and self-motion patterns and are controlled and coordinated by certain patterns in the cerebral cortex. The involvement of these systems is proportional to automatic reactions and includes predictable changes in muscle consistency along with head and trunk posture. These changes are associated with the increased matching of flexor and extensor muscle activity to restore balance [3]. According to the information, it can be claimed that combined strength and proprioceptive exercises have a significant effect on the balance and gait speed of mentally retarded children.

The results of the present study showed that 8 weeks of combined strength and proprioceptive training has a significant effect on the strength of the lower limbs of intellectually disabled children. The results of previous researches that studied the effect of exercise programs on the strength of mentally retarded children are in line with the findings of the present research. Oviedo et al. (2014) with strength, balance and aerobic exercises [21], Salehzadeh et al. (2013) with Pilates exercises [27], Elmahgoub et al. (2009) with combined sports exercises [28], Shields et al. (2010) with progressive resistance training [29], Kubilai et al. (2011) with balance and posture exercises [24], Zolqadr et al. (2019) with the selected corrective-balancing program [18], Matsuda et al. (2020) with sit-up exercises [6], and Lee et al. (2016) with the strength training [12], reported significant improvements in lower limb strength and endurance of intellectually disabled children. Kong et al. (2019) confirmed the effect of Tai Chi exercises on improving physical fitness in mentally retarded children and adolescents [11]. Carmeli et al. (2016) posed the question of whether physical activity has an effect on the health and physical fitness of adults with mental retardation? They answered that there are significant differences in muscle strength, health indicators and physical exercises between these people and the healthy group [30]. It is also possible to expect positive changes in the physical fitness of mentally challenged students with the educational programs of various sports fields; For example, these people can improve their muscle strength by participating in basketball training programs [28].

The demonstration of maximum strength depends on the amount of tension of different muscle groups, which is regulated in the cerebral cortex and is one of the mechanisms that ensure the conditions for body preservation [31]. Since the cerebral cortex is disturbed in mentally retarded children, it can be assumed that the structure of the cortical work regulating muscle tension is also disturbed in them [32]. The presence of more and bigger muscles in the lower limb, as well as the fact that there are usually more activities performed with the feet, are possible reasons for increasing the lower limb strength in this study. Also, among the physiological reasons for improving strength, we can refer to the neural changes that lead to effective muscle function, increased nerve activation, simultaneous increase in the activity of motor neurons and decrease in the inhibitory action of the Golgi-tendon organs. Golgi-tendon organs are more sensitive to muscle active force than passive stretching. When a muscle becomes active and starts to generate force, the organ of the Golgi tendon increases its stimulation rate in proportion to the size of the contraction; This information is sent to the spinal cord, where it inhibits the motor neurons of the active muscle and its cooperating muscles and stimulates the opposing muscle through contact with the Interneurons [33].

It seems that physical activity improves physical and motor performance by changing the role of musculoskeletal factors affecting movement, improving the joints range of motion and improving the

parameters involved in motor performance, and by controlling body alignment and facilitating movement learning. The results indicate that the use of combined exercises that affect several parameters involved in motor and physical performance is more beneficial than activities that only focus on improving one parameter.

CONCLUSION

In general, it can be concluded that combined strength and proprioceptive exercises lead to the improvement of physical fitness factors including balance, gait speed and lower limb strength of mentally retarded boys. Therefore, it is suggested to the trainers of exceptional schools and welfare and rehabilitation centers to use a combination of strength and proprioceptive training programs when dealing with such people. The limitations of the present study include the small number of subjects and the inability to control sports activities outside of sports training. It is suggested that the effects of combined strength and proprioceptive exercises on the improvement of ankle and knee proprioception and the strength and endurance of trunk muscles should be investigated in future studies.

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اثر یک پروتکل تمرینی هشت هفته‌ای متمرکز بر ترکیب تمرینات قدرتی و حس عمقی بر عملکرد تعادلی و حرکتی پسران کم توان ذهنی آموزش پذیر

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یکی از چالش‌های اساسی کودکان کم توان ذهنی شیوع بالای مشکلات راه رفتن و تعادل به دلیل ضعف عضلانی می باشد؛ هدف از تحقیق حاضر، بررسی اثر یک پروتکل تمرینی هشت هفته‌ای متمرکز بر ترکیب تمرینات قدرتی و حس عمقی بر عملکرد تعادلی و حرکتی پسران کم توان ذهنی آموزش پذیر بود. ۳۴ پسر کم توان ذهنی ۹ تا ۱۳ سال از بین افراد در دسترس انتخاب و بطور تصادفی به دو گروه تجربی (۱۷ نفر) و کنترل (۱۷ نفر) تقسیم شدند. گروه تجربی به مدت هشت هفته تمرینات ورزشی منتخب را انجام دادند و گروه کنترل در هیچ برنامه تمرینی منظمی شرکت نداشتند. تعادل ایستا، تعادل عملکردی، قدرت اندام تحتانی و سرعت راه رفتن قبل و پس از دوره تمرینی اندازه‌گیری شد. نتایج مطالعه حاضر نشان داد پروتکل ترکیبی تمرینات قدرتی و حس عمقی اثر معناداری بر تعادل ایستا ($p=۰/۰۰۱$)، تعادل عملکردی ($p=۰/۰۰۱$)، سرعت راه رفتن ($p=۰/۰۰۱$) و قدرت اندام تحتانی ($p=۰/۰۰۱$) دارد. در گروه کنترل، تغییر معنی‌داری مشاهده نشد. تمرینات ترکیبی قدرتی و حس عمقی منجر به بهبود عملکرد تعادلی و حرکتی کودکان کم توان ذهنی می گردد؛ از این رو، پیشنهاد می شود از این پروتکل تمرینی جهت بهبود عوامل آمادگی جسمانی کودکان کم توان ذهنی استفاده شود.

واژه‌های کلیدی: پسران کم توان ذهنی، سرعت راه رفتن، تعادل عملکردی، قدرت اندام تحتانی