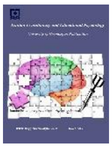
Original Article



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Comparison of Skill-Based, Strength-Based, and Combined Training on Eye-Hand Coordination in Educable Children with Intellectual Disabilities

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Abstract: This study examined the effects of skill-based, strength-based, and combined training programs on eye–hand coordination in educable children with intellectual disabilities. Using a quasi-experimental pretest–posttest design with a control group, the study involved female elementary students with intellectual disabilities in Isfahan, Iran, during the 2012–2013 academic year. Thirty-four students aged 7–14 years (mean age 12.26±1.89) were selected through convenience sampling and evenly assigned to four groups based on pretest scores. The three experimental groups participated in their respective training programs for eight weeks (three 45-minute sessions per week), while the control group followed routine school activities. Eye–hand coordination was assessed using the Vienna Test System (MLS) tracking task (Form S2), which measures number of errors, error time, and total time. Data were analyzed using mixed-design ANOVA (4 groups × 2 phases) and Bonferroni post-hoc tests in SPSS 21. Results showed that all three training programs significantly reduced the number of errors ($p<0.05$). Skill-based training, similar to the control group's routine activities, did not significantly change error time ($p\geq0.05$). In contrast, both strength-based and combined training produced significant reductions in error time ($p<0.05$). Overall, combined training yielded the most comprehensive improvements across measures. These findings indicate that structured physical activity—particularly programs incorporating strength or multimodal components—can effectively enhance eye–hand coordination in educable children with intellectual disabilities. Integrating such targeted exercise interventions into their weekly schedule may support better motor functioning and contribute to improved daily performance.

Keywords: Intellectual disability, Eye-hand coordination, Vienna Test System, Exercise training

Introduction

Despite advances in global health and medical science, intellectual disability remains one of the major challenges facing human societies and is considered one of the most complex and difficult problems among children and adolescents (Roy, 2012; Mohammadkhan Kermanshahi, 2008). In individuals with intellectual disabilities, general intellectual functioning is significantly below the average level expected for their chronological age and is accompanied by deficits in adaptive behavior (Akhavan Karbasi et al., 2011; Pooravanji & Ghofrani, 2009). Approximately 85% of individuals with intellectual disabilities are classified as educable, with an intelligence quotient (IQ) ranging between 50 and 70 (Hadian et al., 2007).

The World Health Organization estimates that approximately 978 million people worldwide live with disabilities, accounting for about 14% of the global population (Nasiripour et al., 2013). Individuals with intellectual disabilities represent a large subgroup within the disabled population, comprising about 1–

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3% of the world's population (Nagarkar et al., 2014; Behjati et al., 2013; Ahmad & Phalke, 2009; Nasiri et al., 2012; Aghaei et al., 2006). This population is estimated to exceed 300 million people globally, a considerable proportion of whom are children and show high potential for rehabilitation and improvement (Pooravanji & Ghofrani, 2009; Asl Aminabadi & Balaei, 2007). In Iran, it is estimated that approximately 1.5–3 million exceptional children live with disabilities, including at least 200,000 students with intellectual disabilities (Shakibaei et al., 2013; Aghaei et al., 2006).

Movement is a fundamental component of life and plays an essential role in all aspects of human functioning. Motor skills are particularly important in children's learning processes and provide the foundation for the development of other important abilities, including academic and social skills (Yarmohammadian & Shafie-Alavijeh, 2012).

Among the five senses, vision is the most important channel for perceiving and receiving environmental information in higher vertebrates, especially humans (Siminghalam & Hussain, 2011). The hands are also vital organs for interacting with the environment and are frequently used in performing everyday life skills (Hadian et al., 2007). Typically, before the hands initiate movement toward a target, the eyes fixate on the target, indicating that visual input provides essential environmental information for guiding hand movements (Ahmadzade et al., 2014).

Eye–hand coordination is a prominent motor skill that forms the basis of perceptual–motor functioning in daily activities, sports skills, and many other motor tasks (Kumar Srinivasan, 2011). It refers to the ability to identify an object (figure) among surrounding objects (background) and coordinate perceptual information with hand movements. In other words, eye–hand coordination occurs when a child can effectively integrate visual perception with body movements, particularly hand movements (Ahmadzade et al., 2014).

Research in the field of intellectual disability has consistently shown that these children lag behind their typically developing peers in motor proficiency and developmental skills (Faal Moganloo et al., 2013). Significant differences have been reported in abilities such as limb coordination, eye–hand coordination, hand movements, and movement speed (Yarmohammadian & Shafie-Alavijeh, 2012).

Several studies have also demonstrated that physical education programs positively influence motor performance variables such as strength, balance, and overall physical condition in individuals with intellectual disabilities (Faal Moganloo et al., 2013). Regular motor training programs can also play an important role in facilitating the return of individuals with intellectual disabilities to more independent and normal life conditions (Gheiji et al., 2014).

For example, Ahmadzade et al. (2014) found that both traditional local games and computer games significantly improved eye–hand coordination in children aged 7–10 years. Similarly, Shaterzadeh et al. (2006) reported that physical practice produced significantly greater improvements in eye–hand coordination than mental practice. In addition, Ghelichpoor et al. (2013) demonstrated that a rope-jumping training program significantly improved eye–hand coordination among elementary school students.

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Given the importance of maximizing the remaining abilities of children with intellectual disabilities (Hadian et al., 2007), physical activity and physical education play a key role in education and rehabilitation by developing both gross and fine motor skills (Faal Moganloo et al., 2013). Therefore, the present study was designed to examine the effects of skill-based, strength-based, and combined training programs on eye–hand coordination in educable children with intellectual disabilities aged 7–14 years.

Material and Methods

The present study employed a quasi-experimental design. The statistical population consisted of all educable female elementary students with intellectual disabilities in the city of Isfahan (392 students) during the 2012–2013 academic year. A total of 34 students were selected purposefully and conveniently from Farshchian and Soroush exceptional schools based on the study's inclusion criteria: age between 7 and 14 years, IQ between approximately 50 and 75 (educable), absence of orthopedic, neurological, or cerebral palsy disorders, no visual or auditory impairments, and parental consent.

Participants were matched based on their pretest scores and then allocated to four groups: skill-based training (n=9), strength-based training (n=8), combined training (n=9), and control (n=8). The training program lasted eight weeks, consisting of three 45-minute sessions per week. Each session included 6 minutes of warm-up, 36 minutes of specific training activities tailored to each group, and 3 minutes of cool-down exercises. Skill-based training included passing, dribbling, and shooting with basketballs and handballs; overhead pass, forearm pass, and serving with volleyballs; and racket–ball movements in table tennis. Strength-based training involved exercises with 1- and 2-kg weights, quadruped crawling, wheelbarrow movement, push-ups, rope pulling, pull-ups, and dumbbell exercises. Combined training consisted of an integration of the skill-based and strength-based programs.

Eye–hand coordination (number of errors, error time, total time) was assessed using the MLS Tracking Test (Form S2) of the Vienna Test System. The MLS apparatus is a 15 × 300 × 300 mm aluminum–brass panel containing various holes of different sizes, a grooved path with multiple geometric shapes, two small metal plates, two rows of 20 small circles, two rows of 25 small holes on the right and left, and two styluses attached to the panel (black for the right hand, red for the left). The test has high reliability (right hand: 0.92; left hand: 0.90) and validity (0.85).

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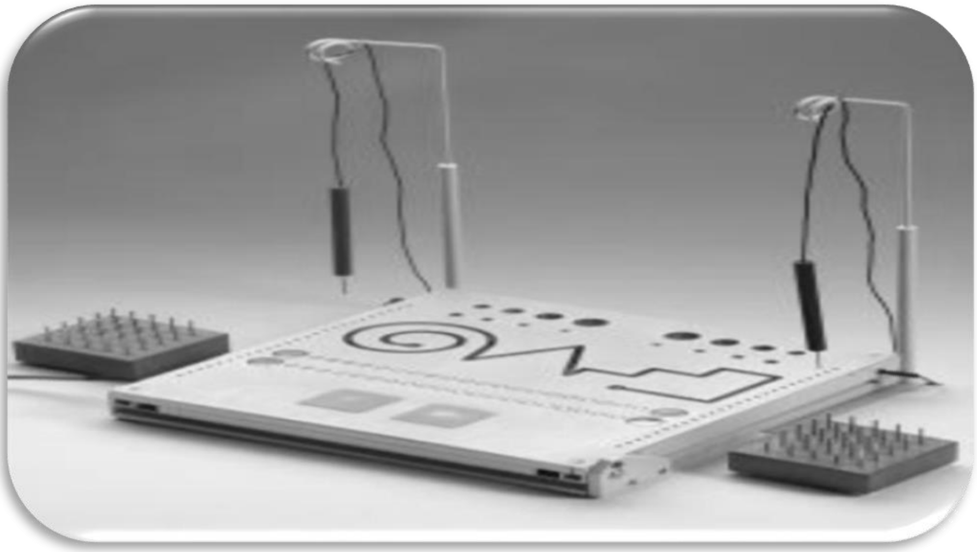

Figure 1. MLS device

The MLS device assesses fine motor abilities in static and dynamic tasks for arm, hand, and finger movements in individuals aged 7 years and older. During testing, the panel was placed on a height-adjustable table, and participants sat on a non-swiveling, armless, non-cushioned chair under adequate lighting. Participants were instructed to move the stylus vertically along a spiral groove without touching its edges or bottom. To begin, they placed the stylus at the bottom of the starting point, and upon completing the path, at the bottom of the endpoint to register the result. Both accuracy (avoiding contact) and completion time were recorded. Each participant performed the tracking test twice (pretest and posttest), and the best score for each phase was recorded. All tests were conducted using each individual's dominant hand (figure 2).

Figure 2. Hand-eye coordination test

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Data analysis was conducted using descriptive statistics (mean ± standard deviation) and inferential statistics with a significance level of $\alpha = 0.05$ in SPSS version 16. The Shapiro–Wilk test assessed data normality, and Levene's test was used to examine homogeneity of variances. A mixed-design (4 groups × 2 tests) ANOVA was used to determine training effects, and one-way ANOVA was applied to compare groups.

Results

The mean age of the participants was 12.26 ± 1.89 years. Given the sample size, the Shapiro–Wilk test was used to assess the normality of the data, and the results indicated that all variables followed a normal distribution ($p \geq 0.05$). The findings showed that skill-based, strength-based, and combined training programs significantly improved the dependent variable of eye–hand coordination errors. In all three training groups, the number of errors decreased significantly from pretest to posttest (all $p < 0.05$). In contrast, no significant difference was observed in the control group following routine daily activities ($p \geq 0.05$) (Table 1).

Table 1. Effects of Skill-Based, Strength-Based, Combined, and Control Conditions on the Number of Eye–Hand Coordination Errors

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Mean Difference (i–j)	Std. Error	p-value
Skill	44.11 ± 9.03	34.11 ± 6.41	10.000	2.659	*0.001
Strength	37.62 ± 5.37	29.50 ± 9.74	8.125	2.821	*0.007
Combined	43.33 ± 14.90	33.22 ± 11.42	10.111	2.659	*0.001
Control	34.75 ± 7.22	30.50 ± 3.74	4.250	2.821	0.142

Significant at p < 0.05

The results indicated that skill-based training did not significantly improve error time in eye–hand coordination among educable children with intellectual disabilities ($p \geq 0.05$). However, both strength-based and combined training programs significantly reduced error time (both $p < 0.05$). Daily routine activities in the control group did not produce significant changes ($p \geq 0.05$) (Table 2).

Table 2. Effects of Training Programs on Error Time in Eye–Hand Coordination

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Mean Difference (i–j)	Std. Error	p-value
Skill	14.00 ± 6.36	10.55 ± 6.15	3.406	2.239	0.139
Strength	18.06 ± 12.57	12.45 ± 6.20	6.118	2.375	*0.015
Combined	18.20 ± 11.52	10.00 ± 5.16	8.153	2.239	*0.001
Control	13.08 ± 5.60	12.63 ± 7.20	0.446	2.237	0.852

Significant at p < 0.05

Based on the results, the main effect of training (pretest vs. posttest) was not statistically significant for total time in the eye–hand coordination task ($F(1,30)=2.468$, $p=0.127$, Partial $\eta^2=0.076$). Furthermore, no significant interaction was found between the training factor (pretest–posttest) and the four training groups ($F(3,30)=0.809$, $p=0.499$, Partial $\eta^2=0.075$). Therefore, no meaningful within-subject interaction was observed. Consequently, there were no significant differences among the effects of skill-based, strength-based, combined, or control conditions on total eye–hand coordination time (all $p \geq 0.05$) (Table 3).

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Table 3. Effects of Training Programs on Total Time of Eye–Hand Coordination

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Mean Difference (i–j)	Std. Error	p-value
Skill	32.28 ± 10.60	29.20 ± 9.01	3.086	3.593	0.397
Strength	27.00 ± 13.15	25.57 ± 6.91	1.425	3.811	0.711
Combined	32.37 ± 12.04	25.00 ± 7.94	6.418	3.593	0.060
Control	26.80 ± 8.56	27.08 ± 5.81	0.291	3.811	0.940

Discussion

Improvement in eye–hand coordination is essential for performing activities that require precise manual skills (Zare & Jahanara, 2013). Among school-aged children, this coordination is necessary for object manipulation, specific games, handwriting, and drawing (Zerbee, 2010). Supporting this, Marshall et al. (2003) reported that structured physical activity programs play an important role in facilitating the functional rehabilitation of individuals with intellectual disabilities.

The findings of the present study demonstrated that skill-based exercises significantly improved the number of eye–hand coordination errors but did not produce significant improvements in error time or total time. In contrast, strength-based and combined exercises significantly improved both the number of errors and error time, while none of the training methods significantly affected total time. Comparison of the three intervention groups with the control group revealed no significant between-group differences in overall improvement across the three dependent variables (number of errors, error time, total time).

Most previous studies accessible to the present researchers have focused on the effect of specific games or physical activities on eye–hand coordination, rather than examining the three components of number of errors, error time, and total time. Moradi and Hirani (2012) indicated that ball sports exert positive effects on eye–hand coordination, and similar findings have been reported for activities such as throwing, striking, dribbling, and ball handling (Lynch, 2011; Zerbee, 2010). Research on tennis and badminton has shown improvement in agility and eye–hand coordination (Atkinson, 1979), and several studies examining tennis training also support these results (Paul et al., 2011; Sahan & Erman, 2009).

Strength training has also been reported to enhance eye–hand coordination (Pawlus et al., 2013), and rope-jumping programs have demonstrated similar benefits (Ghelichpoor et al., 2013). Trikha and Sharma (2014) found that handball training improves shoulder-arm coordination more than basketball, whereas basketball produces greater effects on eye–hand coordination. Other studies on basketball (e.g., LTPD Canada, 2005; Oshawa, 2014) similarly highlight its positive impact. Handball training has also been shown to be effective (Bana et al., 2014).

Fridni (2008) reported that sports-vision, darts, and combined training significantly enhanced eye–hand coordination (error percentage and total time), which is consistent with several components of the present findings. Some occupational-therapy literature also suggests that ball-related activities improve eye–hand coordination (Weissmeh, 2000; Farahbod, 2010). Basirati (2011) showed that table tennis training improved eye–hand coordination (error time) among university students, which contrasts with the present study. This discrepancy may be attributed to differences in participant characteristics, the

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structure of the training program, and the nature of the skills practiced. In the current study, skill components were practiced separately, potentially reducing speed-related benefits.

Furthermore, Weismayr (2000) emphasized that, due to the cognitive and motor limitations of children with intellectual disabilities, training often requires part-to-whole methods, which may limit performance improvements. Another potential explanation relates to the training period: participants in the current study had no prior experience with ball sports, and eight weeks may have been too short to produce significant changes in more complex variables such as total time.

Studies on traditional games (e.g., Asghari-Nekah, n.d.) also indicate improvements in eye–hand coordination, bimanual coordination, and perceptual-motor skills, and other research has shown meaningful effects of perceptual-motor tasks involving ball throwing (Kuhestani, 2003). Muscle strength is a fundamental component of coordinated movement, and higher levels of strength, speed, and endurance facilitate coordination development (Dunway, 1996). The lack of significant improvement in total time in the present study may relate to difficulties participants experienced in understanding test instructions—an issue noted frequently in populations with intellectual disabilities, who may struggle with reasoning, rule comprehension, and position recognition.

Age may also explain the absence of significant differences among the three training groups. Several researchers argue that eye–hand coordination develops through staged growth, with the second developmental phase emerging around age seven; thus, any physical activity may promote natural improvements. It is possible that the control group also experienced developmental gains due to age-related progression. However, the literature remains inconclusive regarding whether the developmental trajectory of coordination in children with intellectual disabilities mirrors that of typically developing children. Fridni's (2008) findings—showing no significant differences among three training modalities—are consistent with the overall pattern of the present study.

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Conflict of interest: The researchers did not report any conflict of interest during the study process.

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