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Comparison of Computer-Based and Therapeutic Activity Interventions for Improving Visual Motor Abilities of Preschoolers with Autism: A Randomized Control Study

Abstract

Background: The purpose of this study was to evaluate the effectiveness of a computer-based and a traditional activity/practice-based intervention for improving the visual motor abilities of children with autism.

Methods: A group, pre-post, experimental design was used with randomization of subjects to four intervention conditions: a computer-based training, a therapeutic practice intervention, the combination of a computer-based training and therapeutic practice intervention, and a martial arts exercise. A sample of 34 preschool children with autism and visual motor integration deficits between 3 and 5 years of age were recruited. The Wide Range Assessment of Visual Motor Abilities was administered pre and postintervention to measure visual motor integration abilities and response to treatment. Group differences at posttesting were analyzed using a one-way analysis of variance, and paired t-tests were used to evaluate change in visual motor integration skills for each groupfollowing the intervention.

Results: The results showed a significant improvement in visual motor abilities in the therapeutic practice intervention group and the combination of computer-based training and therapeutic practice intervention group. The computer-based training and martial art groups did not yield significant results.

Conclusions: The results of this study can provide important information to therapists, teachers, and other related professionals as well as parents and consumers about the effectiveness of traditional therapeutic practice and the combined computer-based and traditional therapeutic practice treatments for preschoolers with autism. Future research on computer-based training in preschool children with autism is warranted.

Keywords

technology, occupational therapy, visual perception, children, treatment strategies

Cover Page Footnote

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Credentials Display

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One role of the occupational therapist in an educational setting is to use assistive/computer technology to support students' academic success. Many academic tasks in school rely on the integration of visual and motor skills, as opposed to visual or motor processing in isolation (Ratzon et al., 2009). Children with autism spectrum disorder (ASD) may have difficulties performing tasks in school. Intervention strategies may focus on visual motor abilities, which are important skills for play; reading; writing; as well as performing daily activities, such as dressing and eating.

Visual motor integration refers to the coordination of visual perception and body movements (Beery, 2004; Ercan et al., 2011; Idoni et al., 2014). Visual perception consists of both reception and cognition of visual stimuli (O'Brien & Kuhaneck, 2020). It is defined as "visual information processing, such as visual-analysis, visual-spatial, visual-motor integration, and auditory-visual integration" (Idoni et al., 2014, p. 170). Visual motor integration deficits occur when there is the disintegration of visual, cognitive, and motor processes (Dankert et al., 2003; Schneck, 2010; Todd, 1999). A visual motor dysfunction can result in functional problems such as difficulties with academic skills, participating in school activities, reading, writing, eating, and locating objects in the environment (Ercan et al., 2011; Schneck, 2010).

Literature Review

Autism is a complex developmental disorder and the fastest growing developmental disability. Autism usually appears within the first 3 years of life. It is one of the most prevalent disorders affecting children today. Prevalence of autism in the United States is estimated at 1 in 54 births (Autism Society of America, 2021). The effects of this disorder include a broad range of symptoms in the following areas: communication, socialization, and atypical repetitive motor and cognitive behaviors that impede on normal development and functioning (American Psychiatric Association, 2013). In addition, children with autism often demonstrate visual motor integration difficulties (Green et al., 2016; Milne et al., 2002; Novales, 2006), which can result in difficulties engaging in daily academic and leisure activities (Case-Smith & Bryan, 1999).

Previous research suggests that children with autism have a unique profile of strengths and limitations in relation to visual motor abilities. In regard to limitations, they demonstrate a global processing deficit or local bias when interpreting visual stimuli. More specifically, they tend to focus more on details and less on the complete picture. It was further found that children with autism demonstrate configural processing deficits when spatial relationships are present (Deruelle et al., 2006). In addition, Davis et al. (2006) found that adolescents with autism demonstrated visual attentional dysregulation and decreased contrast sensitivity for pattern detection. Children with autism possess the skill of simple visual completion (visual closure); however, the skill was found to decline as the complexity of the stimuli increased (De Wit et al., 2007).

Green et al. (2016) compared visual motor integration performance and IQ in individuals with ASD and typical development. Participants consisted of 56 individuals with ASD aged 3 to 23 years and 36 typically developing individuals aged 4 to 26 years. Both groups were administered with the Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery VMI; Beery et al., 2004) and standardized measures of intellectual functioning. It was found that the ASD group performed significantly lower on the Beery VMI and on all IQ measures compared to the typically developing group. Increased difficulties with visual motor integration among children with ASD are evident (Dowd et al., 2012; Mayes & Calhoun, 2007; Narzisi et al., 2013; Reinvall et al., 2013).

Visual motor integration is essential for the development of motor skills. Deficits in visual motor integration found in young children can cause difficulties in play skills, staying in the lines when coloring, cutting, copying, throwing and catching a ball, buttoning and unbuttoning, zipping and unzipping, and writing (Ercan et al., 2011; O'Brien & Kuhaneck, 2020; Schneck, 2010), as well as self-feeding using a spoon (Henderson, 2006).

Therapists implement a number of treatment approaches to target visual perceptual and visual motor deficits. Todd (1999) suggested that by using environmental modifications and teaching strategies, therapists can facilitate development of visual perceptual skills. Furthermore, using compensatory strategies, such as lists, acronyms, mnemonics, chunking, visual and semantic codes, and various rehearsal techniques can assist children with visual memory deficits.

Denton et al. (2006) explored the effectiveness of sensory-motor interventions as opposed to therapeutic practice interventions in regard to improving visual perception. The results determined that the sensory-motor intervention group demonstrated mild improvements in visual perceptual skills over the group that received therapeutic practice intervention. Dankert et al. (2003) targeted visual motor deficits in children with developmental delays. They determined that group-based occupational therapy (OT) sessions focusing on fine and gross motor activities, as well as visual motor and visual perceptual activities (i.e., drawing, cutting, assembly activities) in conjunction with individualized weekly 30-min OT sessions focusing on individualized education plan (IEP) goals were most effective in increasing visual motor and visual perceptual skills as measured by the Visual Motor Integration and Visual Perceptual Tests.

In 2013, Ohl et al. investigated the effectiveness of a 10-week Tier-1 Response to Intervention program in improving fine motor and visual motor skills. Seventy-five kindergartners from general education classrooms participated in the study. The participants' visual motor skills were assessed with the Beery VMI (Beery et al., 2004) and fine motor skills were measured by the Bruininks-Oseretsky Test of Motor Proficiency, 2nd Edition (BOT–2; Bruininks & Bruininks, 2005). It was found that there was statistically significant improvement in the intervention group and no significant findings in the control group.

In addition to the interventions that are currently presented in the scientific literature, the rapidly increasing use of technology today suggests that computers will become an essential part of therapy treatment when addressing visual perception and visual motor abilities.

Coutinho et al. (2017) examined the effectiveness of two intervention strategies: iPad applications and traditional OT interventions in improving visual motor integration. Twenty children aged 4 to 8 years participated in the study. The participants had poor visual motor integration skills as measured by the Beery VMI and the visual motor subscale of the M-FUN. The researchers used a randomized controlled trial design and randomly assigned the participants into the iPad group (experimental group) and the traditional OT group (control group). After the 10-week interventions, no significant results were found for the Beery-VMI, which may result from the small sample size (10 participants in a group). Although no statistically significant differences between the two groups were found, both interventions showed some improvement on visual motor skills. The researchers suggested that iPads may be beneficial in improving visual motor skills when used in conjunction with traditional OT intervention.

In 2012, Dibek conducted a study to examine the effectiveness of Visual Motor Ability Enhancement Program (VMAEP) on improving motor coordination, visual perception, and visual motor integration in 33 five-year old children. The children were assigned into either an experimental group (VMAEP) or a control group (regular education). The Beery VMI was administered to the children before and after the completion of the program. The experimental group received the VMAEP, a multisensory, motor-learning approach three times a week for 10 weeks, which involved read-aloud stories, 3D models and dramatic play, 2D materials, and board games. Dibek found that the experimental group scored significantly better than the control group for visual perception, motor coordination, and visual motor integration.

Cardona et al. (2000) identified that computer intervention was found to be more effective than fine motor activities in improving visual attention of preschool children with disabilities. In addition, Schneck (2010) and Todd (1999) briefly discussed computer interventions as a novel and engaging therapeutic tool.

Computers are unique in that they provide multisensory and interactive experiences that can be graded and individualized to the child's needs. Computers also give the child a sense of autonomy because it allows the child to guide the treatment (Hetzroni & Tannous, 2004). In addition, a computer can be effective for enhancing attention because it may provide visual and auditory reinforcement and salient dynamic visual stimuli, which are particularly beneficial for young children with developmental delays (Cardona et al., 2000). Computers create an intrinsically motivating and fun learning environment that is appealing to children with autism (Moore & Calvert, 2000). Current literature suggests that computers are effective at improving a variety of academic skills in an autistic population. Moreover, many studies have found that computer-based interventions are effective for enhancing other areas of development, such as academic skills (Knight, 2013; Root et al., 2017), social and emotional skills (Ramdoss, Machalicek, et al., 2012), daily living skills (Ramdoss, Lang, et al., 2012), reading comprehension (literacy skills) (Ramdoss, Mulloy, et al., 2011), and phonological awareness (Segers & Verhoeven, 2004).

Although there is abundant literature related to the effectiveness of treatment programs on enhancing academic skills, language, social and communication skills, as well as emotion recognition, there is limited literature available regarding the use of computer-based interventions to address visual motor deficits in children with autism. Furthermore, none of the studies examined the effectiveness of combining the computer-based and therapeutic practice interventions on enhancing visual motor abilities of children with autism. Therefore, the present study was to examine the effectiveness of these treatment strategies: a computer-based training, a therapeutic practice intervention, and the combination of a computer-based training and therapeutic practice intervention on improving the visual motor skills of preschool children with autism.

Research Question 1

What is the effectiveness of a computer-based intervention, an occupational therapy therapeutic practice intervention, and a combined intervention for improving visual perceptual and visual motor abilities in preschool children with autism?

Research Question 2

Are there differences in amount of change in visual motor abilities among preschool children following 8 weeks of OT intervention using a computer-based intervention versus using an OT therapeutic practice approach, or a combined approach or in comparison with control, martial arts condition?

These three intervention strategies are aimed at improving visual motor abilities which are important skills for play, reading, and writing as well as for performing other self-help activities, such as dressing and eating (Coutinho et al., 2017).

Method

A priori power analysis using G*Power 3.1 was conducted to determine a sample size for the study. Thirty-six participants were required to achieve a small effect size of f = .30, power of .80, at an alpha level of .05.

Children with autism aged between 3 and 5 years were recruited using a convenience sampling method and randomly assigned into four groups. Participants were children who fit the following inclusion criteria: (a) were 3 to 5 years of age; (b) had visual motor difficulties as identified by a total score of less than 1 *SD* below the mean on the Wide Range Assessment of Visual Motor Abilities (WRAVMA) test (Adams & Sheslow, 1995), which was administered and interpreted by a licensed occupational therapist; (c) understood and were able to follow both verbal and demonstrated instructions in English; (d) were allowed to participate in the study by parents or guardians; and (e) were diagnosed with ASD as identified by an expert clinician, including a psychologist. Children's medical records and their Individual Education Programs (IEP) were reviewed by occupational therapists to confirm the ASD diagnoses.

Research Design

The research design used in the study was randomized control group pretest-posttest design. There were four groups of participants: computer-based intervention, therapeutic practice intervention, combination of computer-based and therapeutic practice interventions, and a control taekwondo group. The participants were randomly assigned to the groups.

The Study Procedures

The study was approved by the institutional review board. After identifying the participants and obtaining the signed consent forms, the investigator administered the WRAVMA (Adams & Sheslow, 1995) to each participant. The results from the WRAVMA were used as preintervention data and compared to the postintervention data.

The implementation of three types of intervention strategies and one control activity was given to the participants according to groups for 8 weeks, two times a week for 30-min sessions. The interventions include computer-based intervention, therapeutic practice intervention, and the combination of these two interventions. For the intervention groups, occupational therapists, including a licensed occupational therapist and a certified occupational therapy assistant, provided the treatments. The control group participated in Poomse (traditional taekwondo form) activities. The OT students who received Poomse trainings provided these activities to the participants. To enhance the intervention fidelity, all occupational therapists and occupational therapy assistants (occupational therapists) who provided the computer-based intervention practiced and were trained in using the software programs to gain confidence and skills in operating and navigating the activities. The software was downloaded into the central computer of the therapy department so it was readily available. The occupational therapists who provided the therapeutic practice interventions were asked to incorporate a combination of at least three activities into their sessions, including playing with three-dimensional shapes and geometric form boards, tracing over objects and shapes, drawing and copying shapes, coloring shape pictures, and cutting shapes with scissors. The occupational therapists had the authority to use their own clinical judgements on which activities to implement and in which order. The children were also allowed to select activities by giving those activity choices to increase their engagement. This was done to replicate the natural pediatric OT intervention sessions that were not prescribed. Lastly, a black belt taekwondo-trained individual conducted Poomse trainings to all the OT students in person. The video recording of the Poomse moves was shared after the training so that the students could go back to it as needed. Throughout the study, the principal investigator was available for questions and checked in with all therapists and OT students.

This study was a double-blind study to prevent bias in research results. The occupational therapists who provided the intervention were not aware of the group allocations and the participants were unaware if they were in an experimental or a control group.

Group I

The computer-based intervention group consisted of nine participants. The intervention involved using educational computer software called Concepts on the Move (http://www.marblesoft.online) developed for children with special needs to teach visual motor skills. Concepts on the Move included both basic and advanced items consisting of five categories and nine items for each of the categories, such as learning about shapes, size, colors, opposites, same as, occupations, functions, and so forth.

Each participant received a 30-min computer-based intervention twice a week for 8 weeks. The therapists started the session with basic items and moved to advanced items based on the child's skills. The child could choose the categories on which they wanted to work.

Group II

The traditional (therapeutic practice) intervention group included eight participants who were engaged in the following activities: (a) playing with three-dimensional shapes and geometric form-boards, (b) tracing over objects and shapes, (c) drawing and copying shapes, (d) coloring shape pictures, and (e) cutting shapes with scissors.

The participants in this group received a 30-min therapeutic practice intervention twice weekly for 8 weeks. The therapists started with a 5-min warm up session with sensorimotor activities and then a 25-min intervention session.

Group III

The combined computer-based and therapeutic practice interventions group was composed of eight participants. The interventions involved activities described in each of the first two groups. In each session, a child received 4 min of warm-up sensorimotor activities, 12 min of the therapeutic practice, and 12 min of computer-based interventions. The last 2 min were used for closing and transitioning off the computer. Every session followed the same order and the intervention lasted for 8 weeks.

Group IV

The control (taekwondo) group consisted of nine participants who received martial arts activities involving taekwondo forms and moves (Poomse). The forms and moves were basic, such as Left Forward Stance, Left Low Block, Right Forward Stance, Right Body Punch, Right Forward Stance, Right Low Block, Left Forward Stance, Left Body Punch, Left Forward Stance, Left Low Block, and so forth. The participants were engaged in these 30-min Poomse sessions individually for 8 weeks, two times weekly. These activities were led by the OT students.

After the 8 weeks of the intervention phase, the WRAVMA tests were re-administered to the participants by the same occupational therapist who performed the pretest evaluation. These results were used as postintervention data to compare to the preintervention data. The evaluator was blind to the intervention conditions to reduce the risk of bias.

Instruments

An evaluation tool used to collect data in this study was a standardized test: the WRAVMA (Adams & Sheslow, 1995). The WRAVMA is a test of visual motor and visual spatial skills. It is designed for use with children aged 3 through 17 years. It consists of three subtests including Visual Motor (Drawing), Visual Spatial (Matching), and Fine Motor (Pegboard) abilities. These three tests can be administered together or individually. The norms for each subtest were based on a nationally representative sample of 2,600+ children. Its internal consistency coefficients are above .90. Split-half and coefficient alphas for each age group range from .63 to .90. Interrater reliability was done by three examiners. The concurrent validity coefficient between the WRAVMA Drawing Test and the Developmental Test of Visual Motor Integration is .76, for the WRAVMA Matching test and the Motor-Free Visual Perception Test is .54, and for the WRAVMA Pegboard test (dominant, nondominant hand) with the Grooved Pegboard Test (GPT) dominant hand is .35 and nondominant hand is .39.

Overall, the psychometric properties of reliability and validity of the test are within a moderate to high range except the concurrent validity between the WRAVMA and the GTP. The low correlation coefficient between the WRAVMA and GTP may be contributed from inadequate norming of the GPT (Adams & Sheslow, 1995).

The current study used the composite scores of WRAVMA pretest and posttest evaluations in the data analysis. Each of the three subtests measures different areas of visual motor abilities, and administering all three subtests provides a more comprehensive view of visual motor abilities than individual subtests. Besides being used as pretest data, the composite scores were used to determine if the child had visual motor difficulties during the subject recruitments.

The WRAVMA was selected for this study because it is a reliable and valid tool that measures visual motor integration in children aged as young as 3 years. It takes 4–10 min to administer each subtest. This is appropriate for young children with autism that may have shorter attention spans, especially with a paper-pencil test. Moreover, the WRAVMA includes graphics that capture attention and are relevant to young children, such as a train, a balloon, and an animal.

The computer software program used in the computer-based intervention and the combined treatment groups was Concepts on the Move-Basic and Concepts on the Move 2-Advanced software (www.marblesoft.online). There were two compact discs (CD). Each CD contained five categories and nine items. The participants could select any three of the nine items for each of the five categories. The categories on the basic CD included colors, shapes, size, opposites, and "same as." The concept groups on the advanced CD consisted of occupations, functions, categories, "goes with," and prepositions. There were nine examples for each concept. The program also included full color photographs illustrating the relationship between concepts, adult's voice narrating each concept, text appearing to reinforce print awareness, changeable presentation format giving choices of concepts to present, and collecting data to monitor the child's performance.

The Concepts on the Move programs were used because they were developed for children with special needs and included a variety of items that can be selected to match the child's interests and performance levels, as well as interactive and multisensory features with music and a human's voice. In addition, it can collect the child's performance data and monitor the child's progress.

Data Analysis

One-way ANOVA was used to compare differences between the means of preintervention scores for all groups. To evaluate whether there were significant differences in visual motor abilities (composite scores) among the four groups of participants, one-way Analysis of Variance (ANOVA) was used. Post Hoc test: Tukey's HSD test was used to further analyze if significant difference existed between the means of each group. Paired sample t-test identified if the means of pre and posttest data were significantly different in each group. Statistical significance was based on an alpha error probability of 5%.

Results

Initially, 36 children were recruited to participate in the current study, nine children per group; however, two participants (one in therapeutic intervention group and one in combined treatment group) had excessive absences from school during the first 4 weeks of the study and eventually dropped out of the study resulting in a sample size of 34. The participants consisted of 25 males and nine females aged between 37 months and 58 months ($\bar{x} = 46.88$; $SD = 6.63$).

Pretest mean differences were calculated to identify equivalency between groups. It was found that the pretests scores between groups were not significantly different, $F(3, 30) = 0.88$, $p = .966$. One-way ANOVA test results reveal significant difference of visual motor abilities among the four groups of participants, $F(3, 30) = 11.96$, $p = .000$ with a medium effect size (Partial Eta Squared = .063).

Tukey post-hoc comparisons of the four groups show that there were no significant differences between computer-based and control (taekwondo) groups ($p = .591$) and therapeutic practice and combined treatment strategies groups ($p = .667$). The results also revealed that the following pairs were significantly different: computer-based and therapeutic practice ($p = .002$), computer-based and combined treatments ($p = .000$), therapeutic practice and taekwondo (control group) ($p = .036$), and combined treatments and taekwondo (control group) ($p = .002$) (see Table 1).

Table 1

Results of Post-Hocs (Tukey HSD) Comparisons of Treatment and Control Groups (n = 34)

(I) type of treatment groups	(J) type of treatment groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
computer-based	therapeutic practice	-14.79*	3.61	.002	-24.63	-4.95
	computer based and therapeutic practice	-19.04*	3.61	.000	-28.88	-9.20
	taekwondo	-4.44	3.51	.591	-13.99	5.10
therapeutic practice	computer based	14.79*	3.61	.002	4.95	24.63
	computer based and therapeutic practice	-4.25	3.72	.667	-14.37	5.87
	taekwondo	10.34*	3.61	.036	.50	20.18
computer-based and therapeutic practice	computer based	19.04*	3.61	.000	9.20	28.88
	therapeutic practice	4.25	3.72	.667	-5.87	14.37
	taekwondo	14.59*	3.61	.002	4.75	24.43

*The mean difference is significant at the 0.05 level.

The paired sample t-tests indicated statistically significant improvements in the participants' visual motor abilities in all groups ($p \leq .01$) except the computer-based ($t = 2.13$, df = 8, $p = .065$) and taekwondo (control) groups ($t = 1.27$, df = 8, $p = .238$) (see Table 2).

Table 2
Results of Paired Samples t-test for Each Group

		Paired Difference							
					95% Confidence Interval of the Difference				
		Mean	SD	Std. Error Mean	Lower	Upper	T	df	Sig. (2-tailed)
Pair 1	VMA POSTTEST COMPUTER GROUP – VMA PRETEST COMPUTER GROUP	1.22	1.71	.57	-.09	2.54	2.13	8	.065
Pair 1	VMA POSTTEST TRADITIONAL GROUP – VMA PRETEST TRADITIONAL GROUP	21.75	12.95	4.58	10.91	32.58	4.74	7	.002
Pair 1	VMA POSTTEST COMBINED GROUP – VMA PRETEST COMBINED GROUP	27.37	8.45	2.98	20.31	34.43	9.16	7	.000
Pair 1	VMA POSTTEST TKD GROUP - VMA PRETEST TKD GROUP	6.00	14.11	4.70	-4.85	16.85	1.27	8	.238

Discussion

It was shown that both therapeutic practice (traditional therapy) and the combination of computer-based and therapeutic practice (traditional therapy) are effective treatment strategies in improving visual motor abilities of preschool children with autism. This is consistent with the study results of Dankert et al. (2003), Dibek (2012), and Ohl et al. (2013).

Dankert et al. (2003) provided occupational therapy incorporating fine motor and visual motor activities in children with developmental delays. The participants showed significant improvement in their visual motor and visual perceptual skills. In therapeutic practice traditional therapy, the participants were engaged in a variety of activities involving the use of fine motor and visual perceptual skills, such as learning to match shapes on a geometric form board or shape sorter, tracing over objects and shapes with pencil and crayons on paper, drawing and copying shapes, coloring shape pictures, and cutting shapes with scissors. The children were able to choose any of these activities to do during their therapy session, which aided in motivating them to learn and complete the tasks. The participants practiced these fine-motor and visual perceptual skills in every session leading to the significant improvement in their overall visual motor abilities scores.

In Dibek's study (2012), the children who received a multisensory, motor-learning intervention three times a week for 10 weeks demonstrated significant improvement in visual perception, motor coordination, and visual motor integration.

Ohl et al. (2013) implemented a 10-week Tier-1 Response to Intervention program to improve kindergartners' fine-motor and visual motor skills. The participants' visual motor skills and fine-motor skills in the experimental group were significantly improved, whereas children in the control group showed no significant improvement in these two areas.

In addition, Coutinho et al. (2017) concluded that iPad applications and traditional occupational therapy interventions could improve visual motor skills of children aged between 4 and 8 years. They implied that iPad apps intervention could be effective in improving visual motor skills in school-aged children when used in an addition to therapy.

Based on the findings from these studies, it is evident that traditional occupational therapy intervention is effective in improving visual motor skills in young children.

In the present study, although the combined computer-based and traditional therapeutic practice treatments significantly increased the participants' visual motor abilities, computer-based treatment alone did not improve the visual motor abilities of the children with autism. According to Cardona et al. (2000), computer-based intervention was found to be effective in improving children's visual attention because of its interactive features, colorful pictures, and sounds.

Research has shown that computer-based interventions can be effective for use with individuals with ASD because the software programs can be setup to provide immediate feedback, clear routines, expectations, and data collection; however, there were some concerns since computer-based intervention may potentially result in increased social isolation or decreased social interactions in the ASD population (Ramdoss, Lang, et al., 2011).

Although studies on a computer-based treatment have been conducted by many authors, its impact on visual motor skills is still insufficiently explored. Despite the fact that the computer software program used in this study provided wonderful features such as colorful graphics and sounds that could capture the participants' attention, the activities themselves could be found boring after repeating them for several full 30-min sessions, and some advanced categories can be too challenging for the participants. In addition, the child was not able to fully control a mouse to navigate the program. These limitations of the software program, the short 8-week interventions, and a small sample size may have contributed to the non-significant results shown in the computer-based group. The findings in this area are inconclusive and should be further explored while addressing all the issues identified.

With the present's study findings supporting the use of combined therapeutic traditional and computer-based practice as an intervention tool for improving visual motor abilities of preschool children with autism, clinicians may consider integrating both therapeutic practice and technology into their treatment of this population. Future research is warranted to examine the effectiveness of computer-based intervention alone.

Limitations

The study locations in this study were varied depending on the time of year and the children's and parents' schedules. During the school year, the data collection was done mostly at the participants' preschool. In the summer, it either occurred at the participants' homes or at their taekwondo school. The sample size was quite small considering that there were four treatment groups. The therapists were not required to provide the treatment activities in a specific order and the children participants had an opportunity to select what activities on the list they wanted to participate in for each session. This could weaken the intervention's fidelity. In addition, the computer software program used did not allow children to be in full control of the mouse to navigate the activity items and was limited in terms of customizability to specific children.

Suggestions for Future Studies

A larger sample size and a longer treatment duration may yield more significant changes in the intervention groups. The effectiveness of computer-based intervention alone in improving visual motor skills should be further investigated. In the future, instead of using a computer-based software program where a computer is required in therapy, iPad apps that incorporate a variety of visual perceptual interactive features may be examined to find its efficacy in addressing visual motor skills in children with autism.

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