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Feasibility and Effects of Mobile Videoconference-based Parent-Implemented Early Start Denver Model Intervention for Early Autism

Hye Hyeon Kim (hyehyeon2@gmail.com)
Gachon University
Ki Won Choi
DoBrain Co, Ltd
Ye Jin Choi
DoBrain Co, Ltd
So Young Park
Woorisoa Children's Hospital

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Abstract

Parent-implemented Early Start Denver Model (P-ESDM) is an evidence-based early intervention model for toddlers with autism spectrum disorder (ASD). We investigated the effectiveness of a low-intensity, mobile videoconferencing-based P-ESDM intervention, for 20 parents and their toddler with ASD. They were evaluated at baseline and after 3 months of intervention. We conducted stratified subgroup analysis based on participants' characteristics and evaluated feasibility using parent questionnaires. Significant improvement was found in parental acquisition of ESDM intervention skills. However, there were no significant differences in any variables between baseline and after intervention. Stratified subgroup analysis based on ASD severity indicated significant effects on parent-child interaction among parents in the high ASD severity group. Stratified subgroup analysis based on personal health record (PHR) access frequency indicated significant effects on toddler's problem behaviour and parent's stress among high PHR access frequency group. We observed promising feasibility outcomes for P-ESDM intervention through videoconferencing.

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder associated with lifelong impairment in communication, behaviour, and social skills that begins early in childhood. It is known as the most serious and complex disorder among developmental disorders [1]. There has been a rapid increase in the global prevalence of ASD [2]. For instance, in the United States, it is estimated that 1 in 44 children has been identified with ASD (2018) [3]. The prevalence of ASD in South Korea is 2.64% (2011) [4].

Despite the high prevalence, educational programs and parenting information for autistic children and their parents are very scarce, with some educational programs remaining one-time and lecture-based. Therefore, a systematic and verified program is required.

The Early Start Denver Model (ESDM) is a comprehensive early intervention program for children with ASD, aged under 48 months. When ESDM early intervention was performed, cognitive, language, and adaptive behaviours were significantly improved [5]. It was found that the effect of the intervention was maintained even after two years [6]. Other studies indicate that ESDM reduces children's maladaptive behaviours such as self-harm and aggression [7]. Moreover, it increases parental satisfaction and reduces parenting stress, as it allows parents to respond effectively to children's problems [8].

Parent-implemented ESDM (P-ESDM) has been developed as the extended ESDM version to educate parents, so that they may directly intervene in their children's treatment through assistance and coaching from therapists [9]. P-ESDM operates on the same developmental, relationship-based principles as the therapist-implemented ESDM. It fits well with the importance ESDM places on the quality of social skill between children with ASD and their parents. P-ESDM interventions that attempt to improve social interactions in a natural environment have advantages for parents who spend the most time with their children in day-to-day life [10–12]. It also emphasizes the value of family interventions involving treatment of their children.

To determine efficacy of parent-implemented interventions for children's outcomes, many studies have been carried out over the past decade. However, there has been contradictory results so far. In a 12-week P-ESDM intervention, significant improvement was observed among children's spontaneous language, social initiation, imitation, and parental interaction and treatment skills, which were maintained even after termination [4]. In another study, there were no differences in child development, autism level, and parental interaction skills between the P-ESDM and community groups, as both groups of parents improved their interaction skills and demonstrated progress [13]. In a study of P-ESDM using internet telehealth, the level of improvement in interaction skills of parents who received P-ESDM was higher than that of parents in the community group. However, children's outcome differed based on the group and the effects on child's development are yet to be understood [14, 15].

This pilot study examines whether the expected functions appear in mobile-based P-ESDM implementation in a non-face-to-face format. The primary goal of this study is to determine whether P-ESDM is effective for parents and their toddler with ASD, using videoconferencing, with online feedback received using the Personal Health Record (PHR) system [16].

Hypotheses

In previous studies, the proper and expected effects of P-ESDM intervention were classified into four categories [10–14]. Since this study was conducted with low intensity for a relatively short period of 3 months, we hypothesized in anticipation of realizing the first three of the four effects.

1. Parents receiving 12 weeks of P-ESDM intervention will show more skilled use of interactive techniques measured by the P-ESDM fidelity measure.
2. Parents receiving P-ESDM intervention will demonstrate more positive emotional changes such as increasing parenting efficacy and reducing parenting stress.
3. Communication and relationship between parents receiving P-ESDM intervention and their toddlers will be improved.
4. Toddlers of parents receiving P-ESDM intervention will demonstrate greater gain in reducing autism symptoms and problem behaviour and increasing adaptive behaviour and interaction skills.

Results

Participants and Simple Characteristics

Of 37 individuals screened for this study, 14 did not meet the inclusion criteria. Thus, 23 individuals were enrolled. However, only 20 subjects completed the pre-treatment. The demographic characteristics of toddlers and parents are presented in Table 1. A total of 20 toddlers (14 males/6 females) were analysed. They were aged 34.4 ± 6.6 months (min-max: 21–44 months). Parents agreed to participating in P-ESDM because more than half graduated from college and most did not have financial limitations.

Table 1
Toddler and family baseline characteristics.

Variable	P-ESDM (n = 20)
Toddler age, mean (SD)	34.4 ± 6.6
Toddler gender, n (%)	
Male	14 (70%)
Female	6 (30%)
Maternal education, n (%)	
High school	3 (15%)
College	13 (65%)
Graduate or higher	4 (20%)
Family income, n (%)	
30-50K	6 (30%)
50-80K	7 (35%)
>80K	7 (35%)

Feasibility using a parent questionnaire

All participants completed a satisfaction survey (Table 2). For P-ESDM lecture and its efficacy, the parent questionnaires revealed a mean score of 4.24 on a five-point Likert scale, with a score of five indicating ‘strongly agree with the statement’. More than 90% of the participants answered that they understood the lecture content well and that it was effective in applying it to their toddler in real life and having more fun with them. More than 85% of the participants answered that they were satisfied with the non-face-to-face method.

For group and individual coaching, the mean scores were 4.31 and 4.2, respectively. Most (92%) participants answered that it was a good time and opportunity to discuss and to ask questions within the group in the community setting. Moreover, 85% of the participants answered that the supportive attitude of the group members helped in sharing their experiences. Majority participants (95%) were also satisfied with their individual coaching, and this resulted in 80% of parents expressing that they had a better understanding of their child.

For the usefulness of mobile PHR service, the mean score was 3.33. About 40% of parents responded positively as it helped them to check their child's development status, but 45% of them answered that it was only moderately useful. Regarding communication with physicians and therapists, only 35% of them responded positively.

Table 2
Result of satisfaction survey.

Component	Mean (n = 20)
P-ESDM lecture	4.24
Group coaching	4.31
1:1 coaching	4.2
Mobile PHR service	3.33

Change on Parent Fidelity Measure

Table 3 displays all measurement results between baseline (T1) and 12-weeks follow-up (T2). We measured nine tools of four different types, related to parents and their toddler; (1) tools evaluating child's autism and severity (K-CARS, K-SCQ); (2) tools assessing child's outcome related to their developmental status (VABS, CBCL); (3) tools measuring emotional factors of parents such as parental stress and parenting efficacy (PSI, PSOC, FQ); and (4) tools evaluating the degree of parent-child interaction (ESDM fidelity, PCI-D). There was a significant improvement only in ESDM fidelity between measures at T1 and T2 ($p = .0007$).

Table 3. Comparison outcomes of all measurement scores before (T1) and after (T2)

12 weeks P-ESDM intervention.

Measurements	T1 mean (SD) N = 20	T2 mean (SD) N = 20	p-value#
Screeners/ASD Diagnosis			
K-CARS II	33.3(2.6)	32.4(3.1)	0.05251
K-SCQ	15.8(4.6)	14.5(5.6)	0.07175
Developmental Measures			
VABS##	63.8(7.1)	NA	NA
CBCL	47.0(19.6)	45.1(20.7)	0.7111
Parent Measures			
PSI	102.9(18.0)	102.7(17.9)	1
PSOC	45.5(11.7)	46.1(11.9)	0.3747
FQ	55.7(11.3)	52.4(11.3)	0.1904
Parent-Child Interaction			
ESDM Fidelity	36.8(6.3)	42.6(3.8)	0.0007***
PCI-D(P)	24.4(2.5)	25.3(1.9)	0.1629
PCI-D(C)	23.6(4.5)	25.2(3.1)	0.1347
# Wilcoxon signed-rank test; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$			
## More than half of the participants did not submit the result values after P-ESDM intervention.			

Change on All Measurements in Stratified Groups based on ASD Severity

All participants were stratified into two groups based on ASD severity (K-CARS score): CARS high group and CARS low group. We first measured all differences between measures at T1 and T2 in each group. In the CARS low group, there were significant differences among two measurements related to ASD severity: K-SCQ reported by the parents (p = .0137) and K-CARS reported by therapists (p = .0318). However, there was no significant difference in the CARS high group. In both groups, there were significant improvements as reflected in approximately a seven-point increase in ESDM fidelity between measures at T1 and T2. The CARS low group (p = .0059) showed greater improvement than the CARS high group (p = .0411). We also measured the difference between groups for P-ESDM effects by comparing the average value of the difference before and after the P-ESDM intervention. There were significant differences in the K-SCQ (p = .0088) and PCI-D(P) (p = .0416) scores between groups (see Table 4).

Table 4
Comparison outcomes of all measurements scores before (T1) and after (T2) 12 weeks P-ESDM intervention based on ASD severity.

	T1 m(SD) N = 10	T2 m(SD) N = 10	p-value#	T1 m(SD) N = 10	T2 m(SD) N = 10	p-value#	CARS LOW TΔ N = 10	CARS HIGH TΔ N = 10	p-value#
	CARS Low			CARS High					
Screeners/ASD Diagnosis									
K-CARS II	31.4(2.0)	29.8(1.9)	0.0318*	35.2(1.5)	35.1(1.1)	0.8582	-1.7(1.7)	-0.1(1.6)	0.0658
K-SCQ	13.7(5.1)	10.1(4.4)	0.0137*	17.8(3.3)	18.4(3.2)	0.2021	-3.6(2.4)	0.6(1.3)	0.0088**
Developmental Measures									
CBCL	44.3(22.5)	41.7(20.8)	0.6236	49.4(17.3)	48.2(21.3)	1	-2.7(12.7)	-1.2(24.4)	0.9054
Parent Measures									
PSI	102.2(16.2)	101.0(15.1)	0.9593	103.5(20.5)	104.3(21.1)	0.9591	-1.2(8.9)	0.8(14.0)	1
PSOC	46.1(13.0)	47.2(12.6)	0.4061	44.8(10.9)	44.9(11.8)	0.6452	1.1(4.6)	0.1(6.7)	0.6827
FQ	52.0(13.2)	46.7(10.8)	0.1548	59.0(8.6)	57.6(10.0)	0.8783	-5.3(10.5)	-1.4(7.4)	0.5936
Parent-Child Interaction Measures									
ESDM Fidelity	37.8(3.8)	43.0(2.8)	0.0059**	35.9(8.2)	42.1(4.6)	0.0411*	5.3(3.9)	6.2(7.0)	1
PCI-D(P)	24.7(2.0)	24.5(2.1)	0.5716	24.1(3.0)	26.1(1.4)	0.0727	-0.2(0.9)	2.0(2.8)	0.0416*
PCI-D(C)	24.4(4.6)	25.1(2.7)	0.5933	22.8(4.6)	25.3(3.7)	0.1236	0.7(5.4)	2.5(4.2)	0.4395

Wilcoxon signed-rank test; * p < 0.05, ** p < 0.01, *** p < 0.001

Change on All Measurements in Stratified Groups based on PHR Access Frequency

For PHR usage related analysis, all participants were stratified into four groups based on the PHR access frequency. We selected the highest and lowest access frequency groups to examine whether the ESDM intervention effect was different between them. Table 5 displays and compares all measurement results between T1 and T2, of the two groups. There was no significant difference between T1 and T2 in each of the two groups. However, there were significant differences in the mean of the CBCL (p = .0313), PSI-SF (p = .0425), and PSOC scores (p = .0290) between PHR lowest and highest groups.

In CBCL measurement, parents in the group with the highest access frequency tended to answer that their toddler's problem behaviour decreased. However, parents in the group with the lowest access frequency tended to answer that problem behaviour rather increased. The PSI measures the stress level of parenting and the PSOC measures the degree to which parents feel competent and confident in

parenting their toddler. In both measurements, the trend indicated increasing scores in the PHR lowest frequency group and decreasing scores in the PHR highest frequency group. These trends made significant differences between the two groups.

Table 5
Comparison outcomes of all measurements scores before (T1) and after (T2) 12 weeks P-ESDM intervention based on PHR usage.

	T1 m(SD) N = 5	T2 m(SD) N = 5	p-value#	T1 m(SD) N = 5	T2 m(SD) N = 5	p-value#	PHR LOW TΔ N = 5	PHR HIGH TΔ N = 5	p-value#
	Lowest access of PHR			Highest access of PHR					
Screeners/ASD Diagnosis									
K-CARS II	31.1(2.5)	29.9(3.3)	0.2012	32.6(2.7)	32.4(2.7)	0.8918	-1.2(1.6)	-0.2(1.5)	0.9071
K-SCQ	12.5(7.0)	11.25(6.7)	0.1736	14.6(3.6)	12.0(5.4)	0.2207	-1.3(1.0)	-2.6(3.4)	0.3125
Developmental Measures									
CBCL	44.0(23.9)	46.0(28.2)	0.8539	43.3(18.2)	32.6(10.2)	0.2012	2.0(12.1)	-10.8(12.6)	0.0313*
Parent Measures									
ESDM Fidelity	39.7(4.5)	43.1(1.9)	0.1875	39.4(3.7)	44.1(3.4)	0.125	3.4(5.2)	4.7(4.7)	0.6578
PSI	96.4(14.6)	98.4(14.0)	0.4375	107.2(16.6)	98.6(9.7)	0.0625	2.0(4.5)	-8.6(9.1)	0.0425*
PSOC	45.0(11.7)	48.2(10.2)	0.0568	45.2(16.3)	43.6(13.5)	0.3573	3.2(2.6)	-1.6(3.4)	0.0290*
FQ	53.0(5.6)	48.25(10.2)	0.375	60.4(13.3)	59.0(11.0)	1	-4.8(7.8)	-1.4(15.2)	0.7812
Parent-Child Interaction Measures									
PCI-D(P)	26.0(2.9)	25.2(2.8)	0.1736	24.0(1.4)	25.8(2.5)	0.3613	-0.8(0.8)	1.8(3.2)	0.9504
PCI-D(C)	26.0(4.4)	25.0(2.3)	0.8923	24.6(2.6)	26.8(3.8)	0.0890	-1.0(5.8)	2.2(1.3)	0.9498

Wilcoxon signed-rank test; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Discussion

P-ESDM intervention has been proven effective, however it presents conflicting opinions on the area of effect. This pilot study evaluated whether a 12-week P-ESDM intervention was effective for toddlers with autism and their parents, in non-face-to-face videoconferencing environments while using the mobile PHR system.

ESDM is usually an intensive intervention (15–25 hours week for 24 months or more) program with traditional face-to-face or in-person interventions involving high costs and low accessibility [4, 9–12]. However, in our study, it was confirmed that non-face-to-face videoconferencing method could be applied to P-ESDM intervention process as it yielded a high feasibility in the satisfaction survey. It is suitable for parents who do not have enough time due to childcare and are particularly unable to move freely due to the COVID-19 pandemic. We also adopted the smartphone based PHR system. It was highly feasible especially in South Korea as almost all Koreans own smartphones (95% of the adult population). Since the country has the highest penetration of smartphones, access to treatment through smartphones can be beneficial.

We predicted that the 12-week P-ESDM intervention would result in (1) greater parent acquisition of ESDM intervention skills, (2) positive internal emotional changes (reducing parenting stress, promoting parenting efficacy), and (3) improved parent-child interrelationships.

We confirmed the first hypothesis as we found a significant difference in ESDM fidelity in the total sample. This means that parents' interaction skills with children significantly and positively changed after P-ESDM intervention. The main behaviours measured by the ESDM fidelity were core abilities necessary to promote and develop children's interaction. Parents who participated in this study became better at utilizing the skills of promoting the child's development and interaction, than before. It also suggests that parents

understood the contents of P-ESDM and practiced it directly in their daily life with their children. This supports previous research indicating that low-intensity 12-week P-ESDM intervention alone was effective in improving parents' interaction skills [9, 10, 13–15].

Contrary to our second and third hypotheses, we did not find significant pre-post differences for any other measurements. However, we found the feasibility of unconfirmed hypotheses in the subgroup analysis of specific groups. The stratified subgroup analysis was conducted based on participants' characteristics: the degree of parental participation based on PHR access frequency and the child's autism severity.

We confirmed the second hypothesis in the subgroup analysis based on PHR usage. We considered that the frequency of PHR use reflected the active attitude of participants and stratified them into two groups. The highest/lowest PHR access frequency groups were selected among the quartiles for group comparison analysis. Parents in the group with high frequency of PHR usage expressed that their children's problem behaviour decreased, and their stress was reduced based on the results of CBCL and PSI measurements, respectively. This is consistent with previous research indicating that problem behaviour in children with ASD can have a detrimental effect on parent's psychological acceptance, and consequently on paternal mental health [17, 18].

We also confirmed the third hypothesis as a significant difference was found in PCI-D(P) for evaluating the level of parent-child communication upon comparison between high and low autism severity groups. PCI-D(P), the parent-child interrelationship, from the parents' view, was significantly improved in the group with high ASD severity compared with the group with low ASD severity. This indicates that parents of toddler with severe autism experience more ESDM intervention effects regarding interrelationships with their children.

Upon comparison between groups with high and low autism severity, we found significant differences in K-SCQ scores. Screening measurement cannot be changed easily by any interventions, as K-CARS score screened by experts did not differ significantly before and after P-ESDM intervention. However, we found that the K-SCQ score screened by parents' self-evaluation significantly changed after the intervention. In particular, the difference between the two groups of different ASD severity was significantly large. This indicates that the accuracy of parental self-measurement is relatively low than expert measurement. Experts should consider that the SCQ score might fluctuate over time for children with low level ASD severity.

We also found that there was a significant difference in parental self-efficacy between PHR usage groups. However, it was different from what was generally known. Previous research has shown that education programs for parents can reduce parenting stress and increase parental self-efficacy [19]. Similarly, research has shown that parental sense of competence was negatively correlated with parenting stress, that is, mothers with greater self-esteem reported lower levels of parenting stress. In our study, although parents in the group with high frequency of PHR usage reported a significant decrease in children's problem behaviour and parenting stress, their parenting efficacy also significantly decreased. This may be explained by findings of previous research—the complex transactional processes of parenting stress and its related parenting self-efficacy in turn have longer time consequences for well-being and competence of parents. In other words, we can assume that parental self-efficacy measures emotional aspects as self-evaluation of parents own ability. Therefore, it may not have immediate consequences after P-ESDM intervention. Even if the children's problematic behaviour and parental stress were reduced, parenting self-efficacy may not appear immediately. Sufficient time is required to develop a negative relationship between parenting stress and parenting self-efficacy.

There were a few notable limitations to this study. The length of intervention was relatively short and the follow-up time was not sufficient. Thus, this study provides no information on the long-term effect of mobile videoconference interventions. We did not exclude participants that had previously undergone similar interventions or training, making the study population heterogeneous; as the sample size was not sufficient for subgroup analyses according to prior training. Moreover, we had pre-post design without controls. There is also the possibility of a selection bias caused by the recruitment of highly motivated participants.

In conclusion, this study demonstrates that videoconferencing- based P-ESDM intervention can be effective for parents of toddler with ASD. Further studies with larger sample sizes and follow-up time may be helpful for determining the long-term effect of this intervention.

Methods

The ethics committee of Gachon University approved the study. All children received assessment, examinations, and interventions under informed consent signed by their parents. We conducted a prospective observational study from April to July 2021.

Participants

We recruited parents of toddlers at risk for ASD, aged 20–48 months, primarily from paediatricians and online ASD parents' groups for developmental disabilities. Inclusion criteria included:

1. Toddler diagnosed with ASD according to a clinical judgement based on the criteria of ASD in Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [20].
2. Parents submitted a diagnostic report of their child.
3. Parents understood the content of the study and agreed to participate, to receive a 12-week ESDM intervention after having a conversation with the researchers and signed the informed consent during enrolment.

Exclusion criteria included:

1. Toddler with brain injuries
2. Toddler with physical or sensory disabilities
3. More than three consecutive unexcused absences in intervention.

[IMAGE-C:\Workspace\ACDC\ImageHandler\76

Study Design and Procedures

The P-ESDM follows the same principle of applied behaviour analysis, and relationship-based intervention of the ESDM. The parent-delivered intervention was based on the P-ESDM, an evidence-based approach for stimulating developmental growth among toddlers with ASD. Parents self-identified the primary caregiver that would attend the 12, 1.5 hours per-week, mobile videoconferencing intervention, including online real-time lectures, and online group and individual coaching-based sessions. The number of people that a therapist can include in a group is limited. Since it is not efficient to educate all participants at once, they were randomly divided into four groups.

A qualified therapist applied the P-ESDM principles outlined in the manual. The first intervention session was devoted to introducing P-ESDM and learning objectives for the outline. In week 2 and 12, parents were asked to play with their child as they normally would at home, to evaluate parent fidelity performance and child's social communication. Parents were asked to carry out several activities such as playing with preferred toys, playing with toys that child encountered for the first time, and playing without toys for physical activities with parents. For example, the child might prance around, run, and catch. All these fidelity activities were evaluated by the therapist to measure parent's skills and abilities regarding how they manage their child, modulate the child's affect, and use various communication skills. For high validity of ESDM fidelity, research assistants independently rated and compared the scores for inter-rater reliability. The 1:1 individual session was also conducted between parents and the therapist to discuss opinions on P-ESDM treatment, and to monitor the status of parents, toddlers, and parent-toddler interaction.

Session 3–11 followed a specific structure, beginning with 5 min of greeting and a brief chat about the upcoming week, and then proceeding to a 20 min last week check-up. The parents shared their experience using the last P-ESDM topic learned, discussed, and practiced. They were asked to share an example of using the P-ESDM topic with their child, or any strategy they might have. In the next 45 min, the therapist introduced a new topic and coached the parents through several activities and strategies with practical examples based on the intervention theme for each week.

Our P-ESDM intervention had nine topics: (a) principles of learning including Antecedents-Behaviour-Consequences relationships (ABC's of learning) [21]; (b) promoting dyadic engagement and social attention; (c) using sensory social routines; (d) promoting joint activity; (e) enhancing non-verbal communication; (f) building imitation skills; (g) enhancing communication; (h) building functional and symbolic play skills that conducts various methods of play to build intimate relationships with the toddler; and (i) promoting speech development (see Supplement Table 1). In the next 20 min, the parent practiced the techniques in an activity with the assumption that their toddler might be by their side. The therapist provided coaching, encouragement, and feedback on technique

use. Each session concluded with a discussion among group members including generalisation of the new topic to their home and any other topics parents wanted to cover.

Online feedback from the therapist and self-health recording were supported by using our stand-alone PHR (see Supplement Figure 1). Parents accessed the smartphone based PHR system to record the child's health information. It has five features: (a) goal tracking to record daily practice of the P-ESDM topics, child behaviour, especially problem behaviour; (b) medical history such as medication, treatment, adverse events, diagnoses, and symptoms for checking the condition of the toddler; (c) visualized report based on the input data by parent; and (d) FAQs.

The PHR system can be recorded regardless of location and time, and all health records related to autism of a child are integrated to facilitate checking and managing health data at a glance. Only therapists approved by parents were allowed to access health records of their toddler. This allowed therapists to have a better understanding of their toddler, and to provide customised services for ESDM intervention and 1:1 session.

Outcome measurements

Feasibility using Parent Questionnaire

Feasibility was documented through analysis of PHR service utilisation and external evaluation of the P-ESDM, as well as through a questionnaire. It consists of questions regarding the satisfaction and effectiveness of components of the mobile videoconferencing method such as P-ESDM lectures, group coaching, individual coaching, and mobile PHR service (see Table 6).

Table 6
Parent questionaries for feasibility (1 = strongly disagree with the statement; 5 = strongly agree with the statement).

Questionnaire	1	2	3	4	5
P-ESDM Lectures and its efficacy					
I am convinced that P-ESDM is an appropriate treatment for my child					
I believe the therapy to be useful					
My child has more fun playing with me now					
I play a more active role now when playing with my child					
I feel I have had enough time to learn and to practice it with my child					
I communicate with my child with active social interactions					
I am good at drawing attention from my child now					
I was satisfied with videoconferencing method for P-ESDM					
Group Coaching					
I felt sufficiently involved in the treatment through group coaching session					
I believe group coaching was a good environment to share experiences					
The supportive environment from group members was helpful					
I had a sufficient time and opportunity to share and discuss opinions					
I felt more sufficiently involved the P-ESDM through group coaching					
1:1 Coaching					
I could learn about my child's interests and preferences in 1:1 coaching					
I believe individual coaching to be satisfied					
PHR usefulness					
Each function was useful in PHR					
I believe the PHR was helpful to check my child's development status					
I communicate more actively with doctors and therapists with PHR					

Screeners/ASD Diagnosis

Korean-Childhood Autism Rating Scale, Second Edition (K-CARS II). It is a 15-item rating scale completed by the clinician. It identifies children with autism and determines symptom severity through quantifiable ratings based on direct observation [22].

Korean version of Social Communication Questionnaire (K-SCQ). It is widely used as a screening tool for ASD. The K-SCQ is completed by the principal caregiver who is familiar with both the developmental history and current behaviour of the individual with ASD. It was designed as a questionnaire version of the Autism Diagnostic Interview – Revised (ADI-R), the gold standard developmental history measure that is widely used in research and often in clinical practice [23].

Developmental Measures

Korean-Vineland Adaptive Behaviour Scales, Second Edition (K-VABS II). This questionnaire measures the capabilities of both children and adults in dealing with everyday life (i.e., communication skills, motor skills, functionalities needed in everyday life, and socialization) [24, 25].

Child Behaviour Checklist for 1 ½–5 Years (CBCL). This checklist is completed by parents to detect emotional and behavioural problems in children. In the preschool version of the CBCL (CBCL/1½-5), parents who interact with the child in regular contexts, rate

the child's behaviour on a 3-point scale (not true, sometimes true, and true or often true), and are instructed to rate the behaviour as it occurs now or within the previous two months. This delineation differs from the instructions on other age-versions, since rapid development and behavioural changes in the preschool age range are common. The preschool checklist contains 100 questions pertaining to problem behaviour and descriptions of parents' concerns, problems, and strengths of the child [26, 27].

Parent Measures

Parenting Stress Index-Short Form (PSI-SF). Developed by Abidin [28], PSI-SF is a five-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree) with three reverse-scoring items. It includes three subscales with 12 items each: parenting distress (PD), parent–child dysfunctional interaction (PCDI), and difficult child (DC). The PSI-SF score is an indicator of parenting stress associated with parents' anxiety, interactions with their children and child behaviours. Higher scores indicate higher parenting stress.

The Parent Sense of Competence Scale (PSOC). Developed by Johnston & Mash [29, 30], PSOC is a 16-item parent self-report questionnaire designed to measure the degree to which parents feel competent and confident in parenting their children (i.e., efficacy) and the quality of affect associated with parenting (i.e., satisfaction).

The Family Questionnaire (FQ). It is a 20-item, self-administered questionnaire that measures expressed emotion status (criticism and emotional over involvement [EOI]) of family members toward patients with mental illness. The FQ has two subscales: critical comments, and EOI. Each item is rated on a four-point Likert scale ranging from 1 (never/very rarely) to 4 (very often). The FQ is scored by adding together the ratings from the individual items, with higher scores indicating greater levels of expressed emotion [31].

Parent-Child Interaction Measures

ESDM Parent Fidelity Tool. It is a five-point Likert Scale questionnaire about 13 parental behaviours that define the child-centred, responsive interactive style used in ESDM. These behaviours include management of child attention, quality of behavioural teaching to manage inadequate behaviour, giving the child choices, optimizing child motivation for participation in activities, parent ability to modulate the child's affect and arousal, management of unwanted behaviours using positive approaches, parental display of positive affect, parental sensitivity and responsivity to child communications, parental use of multiple and varied communicative functions, appropriateness of parent's language for child's language level, parent's use of flexible joint activity routines with theme, and smooth transitions between activities that maximize child interest and engagement. Parent-child play interactions with a specified set of toys and the instruction to: "play as you typically do at home" were video-recorded at both assessment points. Expert ESDM therapists coded parent behaviours by observing 10-minute videos of these parent-child play interactions [4, 9–10].

Parent Child Interaction-Direct Observation Checklist (PCI-D). Developed by Kyong-Mi [32], PCI-D is a Likert scale which measures parental interactions with children with developmental disabilities. Interaction behaviours are evaluated from each point of view of parents and children, respectively. We observed the time of physical contact, the level of reaction, the level of affection, and the level of emotion. For parents, we observed how they have leadership of play, the level of instruction and questioning, and tone of voice to check for parental responsiveness. For children, we observed response appropriateness, social interest level, and how they react to new toys. Therapists coded parent behaviours by observing 10-minute videos of these parent-child play interactions. The same videos used in ESDM fidelity were utilised.

Data Analysis

Parent-child assessments were collected at baseline, and at the end of the 12-week treatment. Descriptive statistics included frequency (%) and means (M) and standard deviation (SD) for categorical and continuous variables, respectively. All measurement scores were compared between baseline (T1) and 12-weeks follow-up (T2) using the Wilcoxon signed rank test. We also used the change scores between T2 and T1 (Δ = T2-T1) as dependent variables. We also conducted ASD severity-stratified analysis, and subgroup analysis stratified by PHR usage (low, high). All tests were two-sided and were carried out at the 5% level of significance. Statistical analyses were performed using R version (version 3.0).

Declarations

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Author Contributions

H.H.Kim contributed to the concept and design of the study, acquisition, and interpretation of data, drafting the manuscript, and did critical analyses and revising the manuscript. K.W.Choi and Y.J.Choi contributed to the drafting and critically revising the manuscript. S.Y.Park. contributed to recruitment of subjects and the interpretation of in data analysis. All authors reviewed the manuscript.

Competing Interests statement

Dobrain Co. Labs provided played a role in the decision to publish and manuscript preparation. In addition, the authors declare the following employment and financial interests: H.H.Kim and Y.J.Choi are employees at Dobrain co. The views and opinions expressed within this manuscript are those of all the authors and do not necessarily represent those of the sponsor.

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33. Supplement Table 1 Weekly topic and intervention themes of P-ESDM intervention course.

Figures

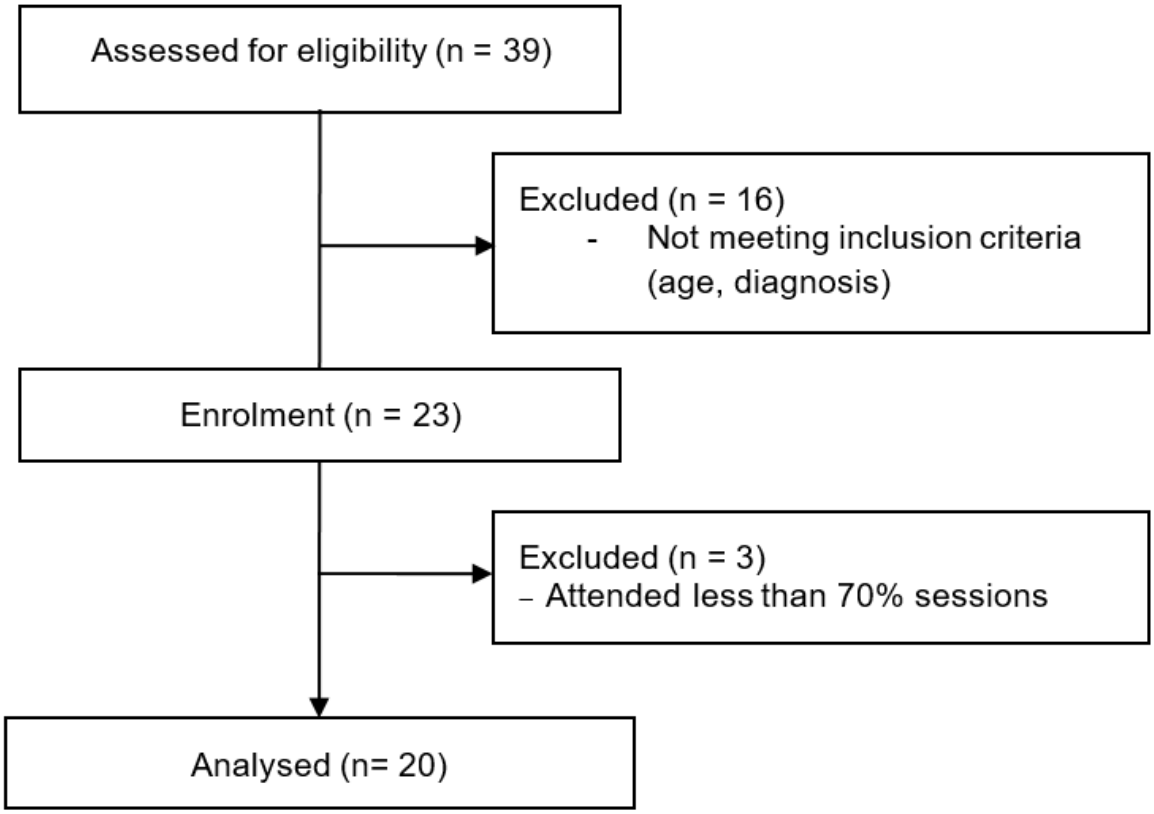

Figure 1

Participant flow chart.

Supplementary Files

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- SupplementTableandFigure.docx