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ORIGINAL ARTICLE

Eye Movement Desensitization and Reprocessing in Young Children (Ages 4–8) with Posttraumatic Stress Disorder: A Multiple-Baseline Evaluation

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Abstract
To reduce the acute and long-term effects of trauma, early and effective treatment is necessary. Eye movement desensitization and reprocessing (EMDR) therapy is a brief treatment for posttraumatic stress disorder (PTSD), with a substantial evidence base for children and adolescents aged 8 to 18 years. In the present study we aimed to provide preliminary evidence of EMDR as a trauma treatment for young children. We studied 9 children, aged 4 to 8 years old with a DSM-5 diagnosis of PTSD. A non-concurrent multiple baseline experimental design was used combined with standardized measures. Participants received six 1-h sessions of EMDR. Results post-treatment showed that EMDR was effective in reaching diagnostic remission of PTSD (85.7%), and decreasing severity of PTSD symptoms and emotional and behavioral problems. All gains were maintained at follow-up 3 months after treatment. EMDR appears an effective treatment for PTSD in young children aged 4 to 8 years. Further research is warranted.

Keywords Posttraumatic stress disorder · Eye movement desensitization and reprocessing · Young children · Multiple baseline experimental design

Introduction

Following exposure to traumatic events, young children may develop posttraumatic stress disorder (PTSD), as well as a range of other mental health problems, such as anxiety, depression or behavioral problems [1, 2]. Young children are at higher risk for exposure to trauma than older children and adults [3]. For instance, compared to other age groups, preschool-aged children have the highest prevalence of maltreatment, including psychical and sexual abuse and neglect [4]. Young children are also more vulnerable to experiencing adverse outcomes following traumatic events, as they have limited coping skills and are strongly dependent on their caregivers for protection and emotional support [2]. Additionally, exposure to trauma during this critical period of brain development can have far-reaching and potentially irreversible consequences on the neurophysiological regulation systems (i.e., structural and functional brain abnormalities in children) [5]. Prospective longitudinal studies show that if left untreated, PTSD during early childhood may follow a chronic and unremitting course. Initial PTSD diagnosis was predictive of that diagnosis three years later [6, 7]. Moreover, childhood adversities are significantly associated with adult psychiatric disorders such as mood disorders, anxiety, substance abuse and disruptive behavior [8]. To reduce the acute and long-term effects of trauma and PTSD, early and effective treatment is necessary.

Unfortunately, effective treatment of PTSD and other trauma-related symptoms in young children (< 8 years old) has been a largely neglected area of research until recently [9]. Practice guidelines for pediatric PTSD recommend two trauma-focused psychological therapies, trauma-focused cognitive behavioral therapy (TF-CBT) and eye movement

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desensitization and reprocessing, EMDR [10–12]. TF-CBT involves a combination of coping skills training, cognitive restructuring, exposure and parent interventions [13]. EMDR is a brief, trauma-focused treatment for PTSD. The core feature is that the patient holds a disturbing image from the traumatic memory in mind while engaging in sets of saccadic eye movements [14]. TF-CBT has the largest evidence base. However, as children under the age of eight were often not included in the randomized controlled trials leading up to these guidelines and age was not used as a moderator in these trials, research into efficacy of these treatments for young children (< 8 years) is in its infancy.

A limited number of studies have explored the efficacy of TF-CBT and EMDR in young children, and those were mainly focused on TF-CBT. To date, four randomized controlled studies examined the treatment efficacy of TF-CBT in young children (range 2–8 years old) with PTSD [15–18]. The preliminary conclusion from these studies is that TF-CBT is effective in reducing PTSD and emotional and behavioral problems in young children and treatment gains were maintained at follow-up (range 3 to 12 months). However, two of the four studies focused on very specific samples (i.e., children exposed to sexual abuse) [15, 16].

In comparison to TF-CBT, EMDR puts less demands on the cognitive and verbal skills and it therefore seems particularly well-suited for young children with PTSD. However, only two non-controlled studies examined the treatment efficacy of EMDR in young children. Hensel [19] conducted a study ($N = 32$, age range 1.9–18 years old) to compare the effectiveness of EMDR in 18 young children (< 8 years old) versus 14 older children who were exposed to single-incident trauma. He found no evidence of a differential treatment effect in younger and older children, suggesting that EMDR may be equally effective for different age groups in reducing parent-reported PTSD symptoms post-treatment and at 6-month follow-up. However, there are important limitations such as no randomization, progress was measured by one measure only (no diagnostic interview), the author was both assessor and therapist, and data were not analyzed by an independent evaluator. The second study that focused on EMDR in young children is a pilot study by Lempertz et al. [20], comparing pre and post intervention PTSD symptoms (15 items from the Child Behavior Check List) to assess EMDR-based group therapy for traumatized refugee preschoolers ($N = 10$, age range 4–6 years old). This study has the same limitations as the study by Hensel [19]. Additionally, attrition was high (40% for the parents, 20% for the teachers) and no follow-up measurement was included. In conclusion, there is a gap in knowledge on the efficacy of trauma treatment for young children with PTSD and other trauma-related symptoms. Especially on the efficacy of EMDR, while this treatment seems very well suited for this specific age group.

In the present study we aim to provide preliminary evidence of EMDR as a treatment for young children (< 8 years). We focused on children between the age of 4 and 8 years old, since the use of EMDR in children younger than 4 years requires a different adaptation of the EMDR protocol. We used a multiple baseline experimental design as it is an ideal experimental strategy for a first evaluation of treatment for a specific group and allows both the intervention process and outcomes to be analyzed [21].[1] We used daily diary measures of the two main PTSD symptoms of each child, thus generating rich data focusing on the concerns that made the caregivers seek help for their child in the first place. This was combined with standardized measures at pre-, post-test and 3-month follow-up. We expected a significant decrease of PTSD symptoms, to the degree that children would no longer meet DSM-5 criteria for PTSD after EMDR therapy. In addition, we expected also a significant decrease in emotional and behavioral problems.

Methods

Participants

The participants ($N = 9$) were referred to a Dutch outpatient mental health clinic for children and adolescents[2] and were recruited between November 2018 and November 2019. Eleven participants were assessed for eligibility. Two children were excluded because they did not meet the full DSM-5 criteria for PTSD. Although there is no universal guideline depicting the minimal replications required to obtain good power in SCED research [23], it is assumed that a sample as small as $N = 3$ can be sufficient to show treatment effects in multiple baseline experimental designs [24]. With nine replications divided among three EMDR therapists, on two different locations of the clinic, the design was robust. Inclusion criteria were (a) age 4 to 8 years, (b) meeting full DSM-5 [25] diagnostic criteria for PTSD established through the Diagnostic Infant and Preschool Assessment, DIPA [26], (c) caregivers were in the possession of a smart phone, (d) participants were to refrain from another form of psychological treatment during the treatment phase of the trial. An exclusion criterium was ongoing trauma (abuse, threats by perpetrator). In that case the primary goal was safety for the child, before trauma treatment could take place.

[1] The Single-Case Reporting Guideline in Behavioural Interventions, SCRIBE [22] was applied in this article. The SCRIBE guideline describes a set of 26 items to guide and structure the reporting of SCED research.

[2] In the Netherlands, all children require a referral by the general practitioner, medical specialists or specialized youth teams in order to receive treatment.

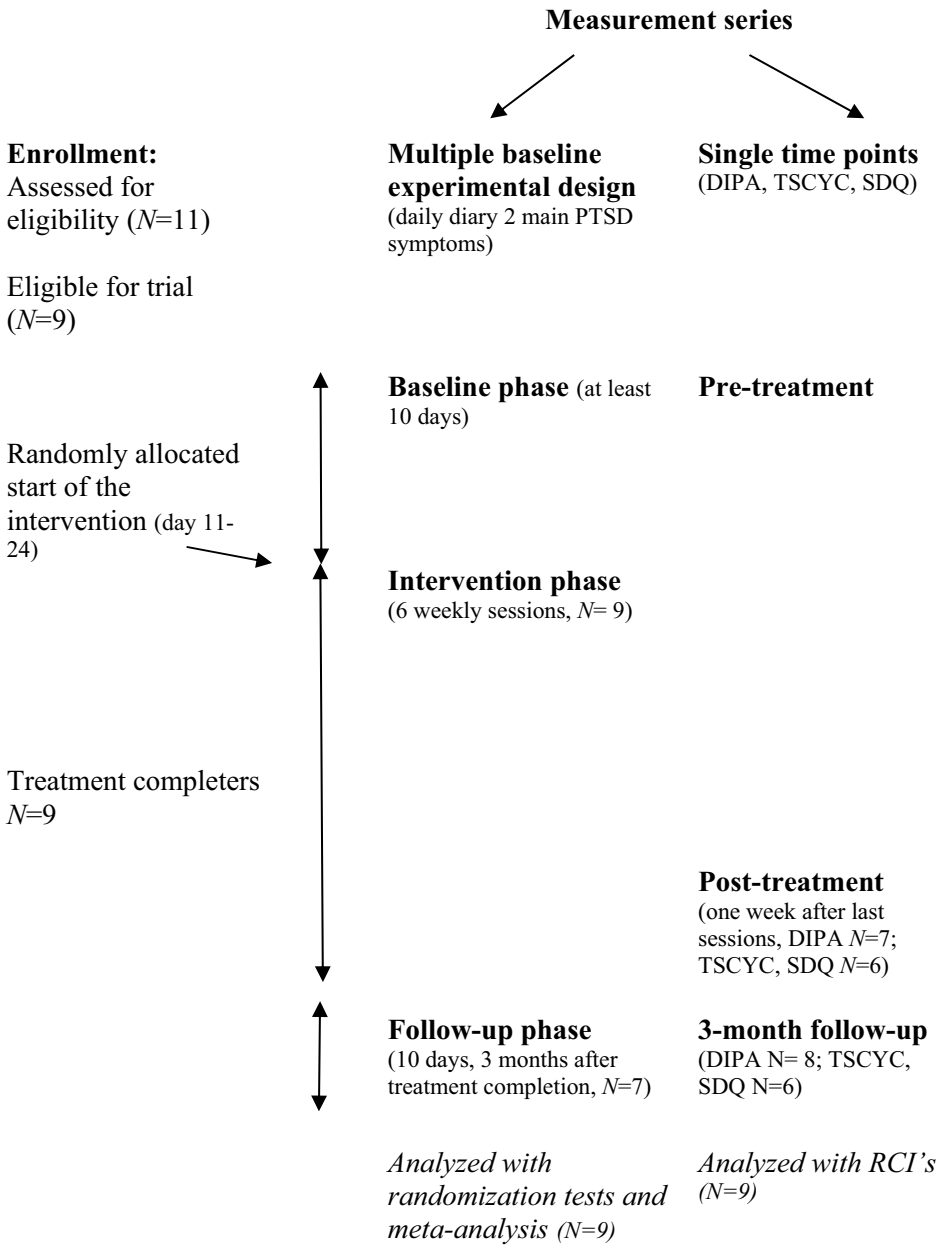

Fig. 1 Flow diagram of participant recruitment and trial progress. *DIPA* Diagnostic Infant and Preschool Assessment, *TSCYC* Trauma Symptoms Checklist for Young Children, *SDQ* Strengths and Difficulties Questionnaire

Study Design

Two different measurement series were performed (see flow chart, Fig. 1):

1. At three single time points (pre-treatment, post-treatment, 3-month follow up) PTSD diagnostic status was assessed using a semi-structured diagnostic interview and PTSD symptoms and emotional and behavioral problems were evaluated by standardized questionnaires (parent-report).
2. Non-concurrent multiple baseline experimental design that comprised of daily measures of the two idiosyncratic main PTSD symptoms by the primary caretaker.

The non-concurrent multiple baseline experimental design was a randomized replicated sequential phase design [21]. The design was made using the RoBiNT Scale [27], a method quality rating scale for internal and external validity of single-case experimental designs.[3] The caregivers of the participants completed daily measures during a no-intervention baseline (phase A), during treatment (phase B) and at 3-month follow-up (phase FU).

The power of individual randomization tests with AB phase designs is usually low. However, replicating the

[3] The design meets 12 of the 15 items, it was not possible to incorporate blinding of the therapists or assessor and inter-rater reliability, since only the primary caregiver filled in the daily diary.

experiment nine times in a randomized multiple baseline design, to differentiate between time effects and effects of the intervention, increases the power considerably [21]. Since participants enrolled at different dates during 1 year, a non-concurrent design was used. For each participant the procedure started as soon as the participant was included. The length of baseline was randomized for each participant between 10 and 24 days. A minimum baseline of 10 days was chosen to observe potential variation in participants before the intervention started.

Treatment

EMDR is a brief, trauma-focused treatment for PTSD and trauma-related symptoms. Treatment followed the standard 8-phase protocol of Shapiro [28], with age-appropriate modifications suggested by Tinker and Wilson [29] and Greenwald [30]. The phases are: history taking, treatment planning, preparation, reprocessing, installation of a positive cognition, check for and processing any residual disturbing body sensations, positive closure and evaluation. We used the Dutch translation of the EMDR protocol for children and adolescents [31]. If the child was exposed to traumatic events before the age of 4, a combined EMDR procedure was used [32] (de Roos ans Beer 2017): EMDR storytelling [33] followed by the standard protocol to ensure complete processing and maximize treatment effect. Participants received six weekly treatment sessions of 1 h. The parents of children 4–6 years old were present in the treatment room during the sessions to support their child and as informant and observer. The parents of the children 6–8 years were present in the room at the beginning and end of each session (about ten minutes in total), informing the therapist about their child's functioning over the past week. At the end of the session the therapist informed the parents about the progress of the session.

All participants were treated by a team of three licensed psychologists who had been trained in EMDR for children level 1 and 2 according to the standards of EMDR Europe.

The therapists followed monthly supervision sessions using video recordings of the sessions from an accredited EMDR Europe trainer for children and adolescents (C.deR.) for the duration of the study to optimize treatment adherence.

Measures

The Diagnostic Infant and Preschool Assessment (DIPA)

The DIPA is a semi-structured diagnostic interview administered to the caregivers of children aged between 2 and 8 years old [26, 34]. It is a diagnostic interview for classifying 16 psychiatric disorders based on DSM-5 for use in research and clinical practice. The PTSD module was used for this present study, to determine inclusion and PTSD diagnostic status post-treatment and at 3-month follow-up. Criteria of PTSD being: (a) the child was exposed to death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence, (b) had one or more intrusion symptoms, (c) had one or more avoidance symptoms or changes in thoughts or mood, and (d) experienced two or more changes in arousal or reactivity. Additionally, symptoms were present at least 1 month and resulted in considerable distress or difficulties in relationships or in school behavior. Internal consistency of the PTSD module was tested good (Cronbach's $\alpha = 0.84$), test–retest reliability was also good with a correlation of 92%. Concurrent criterion validity compared to the PTSD Total scale of the Trauma Symptoms Checklist for Young Children, TSCYC [35] was good, as evidenced by a correlation of 0.82 [34].

Daily Measures of the Two Main PTSD Symptoms

To monitor whether, how and when treatment modified PTSD symptoms, the primary caregiver reported daily on the two main PTSD symptoms of the child. Selection of the items was determined in a pre-trial session with the primary investigator.

The parents selected the two main symptoms of their child by sorting cards with all the PTSD symptoms, derived from the DIPA interview. The items were administered using a secure eHealth app which was placed on the parent's smartphone. The items were constructed using visual analogue scales (VAS), with a range from 0 (*symptom not observed*) to 100 (*symptom observed to the most serious degree*) according to the following formulation: "To what extent did your child suffer from ….today?" Every day at 8 p.m. a reminder was sent to the primary caregiver to fill in the diary.

Trauma Symptom Checklist for Young Children (TSCYC)

The TSCYC [35, 36] is a questionnaire for caregivers of children between 3 and 12 years old. This questionnaire consists of 90 items and measures posttraumatic stress symptoms and related emotional and behavioral problems. On each item caregivers score the frequency of symptoms during the previous month, between 1 (*not at all*) and 4 (*very often*). The 27-item posttraumatic stress subscale was used for the present study to asses PTSD symptoms (total score range = 27–108). To asses other emotional and behavioral problems that can occur following trauma, we used the five emotional and behavioral subscales of the TSCYC: Dissociation, Depression, Anxiety, Anger and Sexual Problems,

each subscale containing nine items (total score range of each subscale = 9–36). Raw scores were converted to T-scores ($M = 50$, $SD = 10$, range = 35–110). T-scores ≤ 64 are considered to be within the normal range, T-scores in the range 65 ≤ 69 are considered as possibly problematic and T-scores ≥ 70 are considered clinically significant.

The PTSD subscale has good internal consistency ($\alpha = 0.92$), with a test–retest reliability of 0.89 [35]. The internal consistency for the emotional and behavioral subscales ranged from $\alpha = 0.78$ to 0.90, test–retest reliability ranging from 0.78 to 0.85.

Tierolf et al. found that the TSCYC significantly correlated with the Child Behavior Checklist scales which measure similar constructs (correlations ranging from $r = 0.28$ to 0.82) [36].

Strengths and Difficulties Questionnaire for Parents (SDQ-P)

The SDQ [37] is a widely used behavioral screening questionnaire that covers children's behavior, emotions and relationships, and focusses on both difficulties and strengths in functioning in children 4 to 17 years old. The 25 items in the SDQ comprise 5 scales of 5 items each: Emotional problems scale, Conduct problems scale, Hyperactivity scale, Peer problems scale and Prosocial scale, the last one measuring strengths of the child (e.g. empathy, friendliness). Items are scored on a three-point Likert-scale (0 = *Not True*, 1 = *Somewhat True*, 2 = *Certainly True*). The total difficulty score is a sum of scores on 4 of 5 subscales (emotional problems, conduct problems, hyperactivity, peer problems), ranging from 0 to 40. Scores below 14 are considered within the normal range, scores between 14 and 16 are considered in the borderline range, and scores between 17 and 40 are considered to be clinically significant [38]. Internal consistency is good (Cronbach's α between 0.70 and 0.80) [39].

Procedure

The Medical Ethics Committee of the Erasmus Medical Centre approved the study protocol. The caregivers of the children between 4 and 8 years old, who had experienced one or more traumatic events and were referred with substantial PTSD symptoms, were approached by the primary investigator to inform them about the study. Caregivers who agreed to participate and signed informed consent, were administered the DIPA by an independent assessor, to determine if the child met full DSM-5 criteria for PTSD. If the inclusion criteria were fulfilled, caregivers were administered the pre-test (i.e., TSCYC, SDQ) and selected the two main PTSD symptoms of their child which were entered into the diary app that was installed on the caregiver's smartphone. The primary caregiver completed the daily measures starting on the day of the pre-test and ending one week after the completion of EMDR therapy. One week after the sixth session, the post-test measures were administered. (i.e. DIPA, TSCYC, SDQ). At follow-up 3 months after treatment, the primary caregiver filled in the diary for another 10 days and the DIPA interview and questionnaires were re-administered.

Statistical Analysis

To analyze the diary data, randomization tests were conducted for each main symptom of each participant. Randomization tests are non-parametric significance tests that are valid for singe-case designs, without making distributional assumptions [21, 40]. The difference between the mean VAS scores in the baseline phase and treatment phase was applied as the *observed* test statistic for the randomization test. To test if the outcomes are real treatment effects instead of natural variation, a permutation test is done comparing the *observed* test statistic to all *potential* test statistics, had the intervention started at any other day than it actually started, days 11–24 after start of the baseline phase. The test statistics are sorted in ascending order. The proportion of potential test statistic values that is as extreme or more extreme than the observed test statistic is calculated and used to define the individual p value of the randomization test. A more detailed description of the randomization tests for single-case experimental designs can be found in Heyvaert and Onghena [40] and Onghena and Edgington [21]. In order to examine the long- term effects of EMDR, randomization tests were done comparing differences between the 3-month follow-up phase and the baseline phase. As the sequential replicated single-case experiments in this study provided independent tests of the same null hypothesis, we were able to combine the p values of individual randomization tests by using Edgington's additive method [41]. A detailed description of this meta-analytic procedure can be found in Onghena and Edgington [21].

Effect sizes were calculated for the daily measures according to the standardized mean differences (SMD) method. We interpreted the magnitude of the SMD's using Cohen's guidelines [42]. All analyses of the daily measures were performed using the Shiny app for Single Case Data Analysis (Shiny SCDA) developed by Bulté and Onghena [43].

To calculate whether a participant's change on the non-daily measures (TSCYC, SDQ) was reliable and large enough to be regarded as statistically relevant, taking into account measurement error, we used the reliable change index (RCI). The RCI is calculated based on the standard error of measurement (SEM) of the questionnaire. RCIs were calculated by subtracting the participant's post-treatment score from the pre-treatment score and dividing by the standard error of difference (S_{diff}) of the questionnaire, with the formula $RCI = x_1 - x_2/S_{diff}$ and $S_{diff} = \sqrt{2(SEM)^2}$. $RCI \geq 1.96$ are considered to be statistically significant (at the 0.05 level).

Table 1 Sample characteristics

Participant	Sex	Age	Trauma type	Frequency (duration)
1	Male	4.5	Medical trauma	Multiple (2.0–3.6)
2	Male	5.1	Domestic violence	Chronic (prenatal–4.1)
3[a]	Male	5.3	Medical trauma	Multiple (0–4.0)
4	Female	7.5	Domestic violence	Multiple (0–4.0)
5	Male	5.4	Medical trauma, domestic violence	Multiple (prenatal–4.6)
6[b]	Female	6.0	Domestic violence	Chronic (0.3–5.6)
7	Female	7.9	Traumatic grief after death of sibling	Multiple (7.6–7.7)
8[a]	Male	5.5	Domestic violence, medical trauma	Chronic (prenatal–5.1)
9	Female	5.11	Domestic violence	Multiple (0–5.4)

Chronic trauma is defined as ongoing domestic violence, constant threat and escalation

[a]Was diagnosed with ADHD after 3-month follow-up and received medication

[b]Received family treatment after 3-month follow-up and trauma treatment was offered to the mother (primary caretaker)

Missing items on the TSCYC were handled in accordance with the manual, there were no missing items on the SDQ.

Results

Compliance and Missing Data

All nine participants received six sessions of EMDR. There was no drop-out from treatment, but the caregivers of three participants (1,7,8) partially failed to complete the assessments post-treatment and the 3-month follow-up. Reasons provided by the caregivers for not finishing the research assessment were that they were overburdened with other personal problems (participants 7 and 8) and lack of motivation to finish the research assessment after treatment (participant 1). The caregiver of participant 1 filled in the questionnaires at post-treatment, but the post-treatment DIPA interview is missing, as well as all follow-up measurements. For participant 7 all post-treatment measurements are missing, but the caregiver filled in the diary at follow-up and also the DIPA interview was administered at follow-up. For participant 8, the questionnaires and diary data are missing at follow up. Only the DIPA interview was administered at follow-up.

Sample Characteristics

Table 1 provides information about gender, age, and type, frequency and duration of trauma. Our sample consisted of five boys and four girls with a mean age of 5.1 years old (mean = 61 months, $SD = 13$). As can be seen in Table 1, children had experienced different types of traumatic events. All participants suffered from PTSD following multiple or chronic traumatic events.

Primary Outcomes

DIPA

Posttreatment, six of the seven tested participants no longer met the criteria for PTSD, which is an 85.7% remission. At 3-month follow-up, seven of the eight tested participants no longer met the criteria for PTSD, which is an 87.5% remission. Both after treatment and at 3-month follow up, only participant 6 still met the criteria for PTSD.

Daily Measures of the Two Main PTSD Symptoms

Figure 2 shows the individual graphs of the scores on the VAS scale (0–100) of the two idiosyncratic main PTSD symptoms as reported by the primary caregivers for each child during the baseline (A, $N = 9$), treatment (B, $N = 9$) and follow-up (FU, $N = 7$) phases, including trendlines for each phase, using least square regression. Visual inspection suggests a modest decline of PTSD symptoms in the treatment phase for most participants. In addition, scores in the follow-up phase seem lower compared to the scores in the treatment phase for most participants, except for the sleeping problems of participant 4 and for both symptoms of participant 6. It is also clear from visual inspection that variability in scores in all phases is high for most participants.

Results of the randomization tests on the daily measures for each participant are displayed in Table 2. While visual inspection suggests a modest decline of the PTSD symptoms, this is not confirmed by the individual randomization tests. This was the case for neither the difference between baseline phase (A) and treatment phase (B) nor between baseline phase and follow up phase (FU) (all p values > 0.05). However, as individual randomization tests tend to lack power [21] we used Edgington's additive method to assess overall effect [41]. This method, that

Table 2 Primary outcome variable: daily measures of the two main PTSD symptoms: randomization test (p-value) and standardized mean differences (SMD) between baseline (A), intervention (B) and 3-month follow-up (FU) per participant and meta-analysis

Participant	Symptom	A–B			A–FU		
		TS	*p*	SMD	TS	*p*	SMD
1	Angry outbursts	20.67	0.09	−0.83	–	–	–
	Sleep disturbance	11.35	0.52	−0.68	–	–	–
2	Hypervigilance	9.72	0.42	−0.65	19.07	0.05	−1.28
	Sleep disturbance	14.18	0.56	−0.85	21.62	0.09	−1.30
3	Negative emotional states	29.07	0.13	−1.06	27.55	0.67	−1.01
	Angry outbursts	36.35	0.09	−1.49	29.79	0.50	−1.22
4	Sleep disturbance	4.05	0.53	−0.46	2.2	0.95	−0.25
	Angry outbursts	17.18	0.11	−0.91	49.26	0.05	−2.60
5	Angry outbursts	7.83	0.27	−0.33	32.38	0.44	−1.38
	Negative emotional states	23.2	0.15	−0.94	46.23	0.06	−1.88
6	Angry outbursts	−1.83	0.82	0.10	−26.63	0.92	1.47
	Sleep disturbance	−1.28	0.19	0.07	−16.38	0.77	0.85
7	Nightmares	6.93	0.53	−0.48	35.91	0.07	−2.50
	Angry outbursts	6.65	0.51	−0.39	36.77	0.07	−2.16
8	Angry outbursts	18.37	0.19	−0.87	–	–	–
	Posttraumatic play	12.06	0.60	−0.83	–	–	–
9	Intense distress	58.7	0.13	−2.68	72.68	0.05	−3.31
	Fear of abandonment	46.46	0.87	−2.15	80.26	0.10	−3.79
Meta-analysis		0.03*			0.02*		

TS observed test statistic

*$p < 0.05$, SMD > 0.2 is small effect size, SMD > 0.5 is medium effect size, SMD > 0.8 is large effect size

combines *p*-values using meta-analysis, demonstrated a significant overall decrease of PTSD symptoms post-treatment ($p = 0.03$) and at 3- months follow-up ($p = 0.02$). Table 2 also gives an overview of the standardized mean difference (SMD), comparing the mean of the baseline condition (A) with either the mean of the treatment condition (B) or the mean of the follow-up condition (FU) of the PTSD symptoms per participant. Comparing the baseline phase and treatment phase ($N = 9$), small (SMD > 0.2) medium (SMD > 0.5) and large effects (SMD > 0.8) were found. For five participants (participants 1, 2, 3, 8 and 9) medium and large effect sizes were found for both symptoms. For two participants effect sizes for one symptom was large, whereas for the other symptom a small effect size was found (participants 4 and 5). A small effect was found for participant 7 for both symptoms. No effect was found on both symptoms for participant 6. Comparing baseline phase and follow up phase ($N = 7$), large effect sizes were found for five participants (participants 2, 3, 5, 7, 9) for both symptoms. A large effect size was found for participant 4 in one symptom, whereas for the other symptom a small effect was found. A large reverse effect in both symptoms was found for participant 6 in the follow-up phase compared to the baseline phase.

Taken together, result on diary data indicate a decline in the two main PTSD symptoms during treatment and a further decline at the 3 months follow up for all participants except for participant 6 and for one of the symptoms for patient 4.

TSCYC PTSD Scale

Table 3 displays the mean T-scores pre-treatment, post-treatment and at 3-month follow-up, and percentages of participants showing a reliable change, comparing post-treatment T-scores and follow-up T-scores with pre-treatment T-scores. For all participants the RCI's were statistically significant, indicating a significant decline in symptoms between baseline and post-treatment and between baseline and 3-month follow-up. Table 4 in the "Appendix" shows the individual T-scores and reliable change indices for each participant.

Secondary Outcomes

TSCYC Emotional and Behavioral Scales

Table 3 displays the mean T-scores pre-treatment, post-treatment and at 3-month follow-up, and percentages of participants showing a reliable change, comparing post-treatment T-scores and follow-up T-scores with pre-treatment T-scores. All participants showed a reliable reduction on the anxiety scale, both post-treatment and at 3-month follow-up. On the depression scale post-treatment all participants except participant 2 showed a reliable reduction. At 3-month follow-up

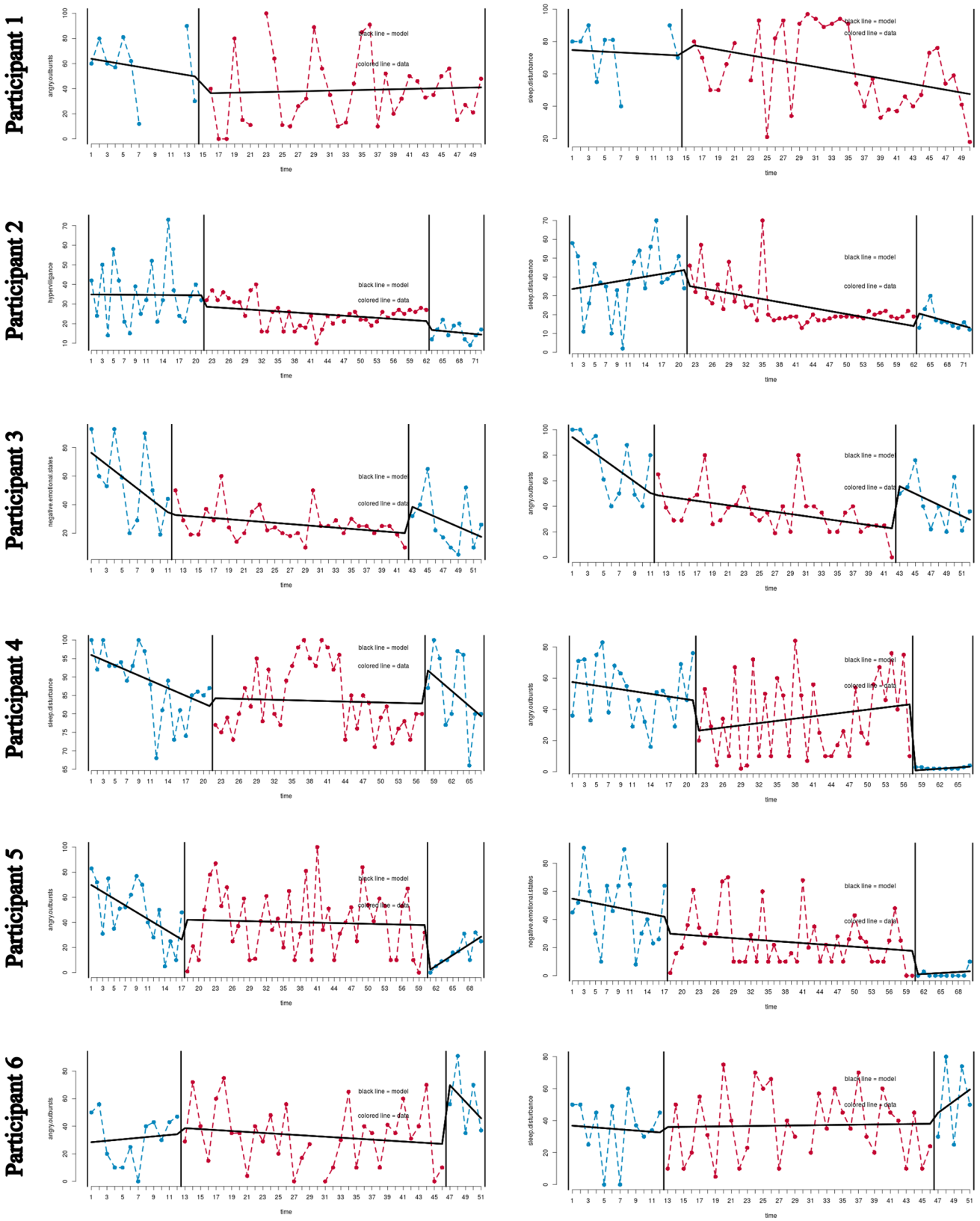

Fig. 2 Primary outcome variable: visual analysis of daily measures (two main PTSD symptoms) for all participants showing the trend of each phase using least square regression

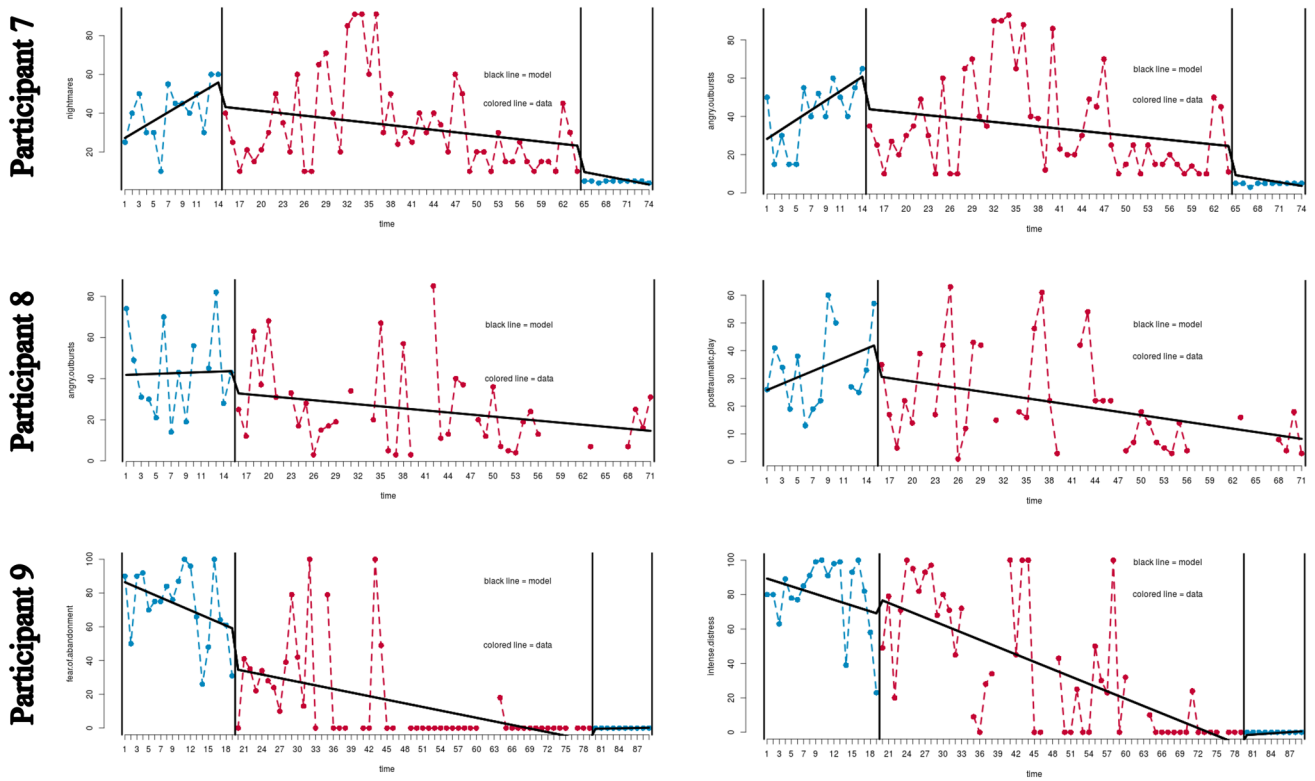

Fig. 2 (continued)

Table 3 Means and standard deviations at pre-, post-treatment and 3-month follow-up and percentages of participants showing a reliable change, comparing post-treatment scores and follow up scores with pre-treatment scores

	Pretreatment	Posttreatment	3 month FU	Reliable change Pre–post	Reliable change Pre–FU
	M (SD)	M (SD)	M (SD)	(%, N = 8)	(%, N = 6)
TSCYC PTSD	99.33 (11.3)	68.12 (11.52)	66 (16.19)	100	100
TSCYC DIS	69.67 (15.43)	53.13 (11.9)	51.17 (16.76)	75	83.3
TSCYC DEP	74.22 (16.74)	53.88 (9.64)	52.83 (11.84)	87.5	100
TSCYC ANX	89.44 (10.31)	70.63 (10.17)	66.33 (14.08)	100	100
TSCYC ANG	77.56 (18.72)	58 (13.99)	50 (7.24)	87.5	100
TSCYC SEX	53.33 (12.98)	49.12 (5.84)	46.5 (0.55)		
SDQ TDS	22.9 (3.6)	16.5 (4)	15 (3.5)	37.5	50

TSCYC Trauma Symptoms Checklist for Young Children, *PTSD* PTSD Total scale, *DIS* Dissociation scale, *DEP* Depression scale, *ANX* Anxiety scale, *ANG* Anger scale, SEX Sexual problems scale, *SDQ TDS* Strengths and Difficulties Questionnaire Total Difficulties Score

participant 2 showed a reliable reduction as well, and the percentage of significant reductions comparing follow-up to pre-treatment was 100%. On the anger scale all participants except participant 4 showed a reliable reduction at post-treatment, and all participants including participant 4 showed a reliable reduction at 3-month follow-up. In conclusion, these results suggest that treatment had a positive effect on anxious, depressive symptoms and anger and the effects remained or further improved at 3-month follow-up.

On the dissociation scale, all participants except participants 3 and 8 showed a reliable reduction post-treatment and at 3-month follow-up. Participant 3 showed an increased T-score at 3-month follow-up compared to pre-treatment score and posttreatment score, however the RCI of this increase was not significant. As the caregiver of participant 8 did not fill in the questionnaires at follow-up, RCI comparing follow-up to pre-treatment scores are missing. On the sexual problems scale, only for two participants sexual problems were reported at the initial assessment. Post-treatment, for both of them there was

a significant reduction that was retained at 3-month follow-up. For the other participants there were no sexual problems reported, which is understandable as none of the participants had sexual trauma. In Table 4 in the "Appendix" the individual T-scores and RCIs for each participant are displayed for the five emotional and behavioral subscales of the TSCYC.

SDQ-P

Table 3 displays the mean scores pre-treatment, post-treatment and at 3-month follow-up, and percentages of participants showing a reliable change, comparing post-treatment scores and follow-up scores with pre-treatment scores. Three of eight tested participants post-treatment showed a reliable reduction posttreatment (37.5%, participants 4, 5 and 9). At 3-month follow-up, 50% of the participants showed a reliable reduction on the Total difficulty score, compared to pre-treatment (participants 5, 6 and 9). Table 5 in "Appendix" displays the individual Total Difficulties Scores and the RCIs for each participant.

Course of Treatment

For all participants the emotionally loaded traumatic memories were all sufficiently reprocessed in six one-hour sessions. Based on the clinical judgement of the therapist none of the participants required extra sessions. Afterwards, all caregivers indicated acceptability of and satisfaction with EMDR therapy. Participant 6 received another form of trauma treatment after the 3-month follow-up, since EMDR was not effective for her. Participants 3 and 8 were diagnosed with attention deficit and hyperactivity disorder (ADHD) after the 3 months follow up, and received medical treatment for ADHD.

Discussion

This study was designed to provide preliminary evidence that EMDR is an effective treatment for young children (4–8 years old) with PTSD. The results of this study suggest that EMDR was indeed effective as remission rate from PTSD diagnosis was 85.7%. Significant reductions in parent-reported PTSD symptoms and comorbid anxiety, depression and anger were found. Importantly, all treatment gains were maintained at the 3-month follow-up. There was no attrition during treatment, supporting the feasibility and tolerance of EMDR in young children. Together the results showed that EMDR had a positive effect on the daily lives of the participants. Since all children suffered from PTSD after multiple or chronic traumatic events (e.g. domestic violence and medical traumas) these results demonstrate that even for these severely traumatized children a brief, six session EMDR therapy was successful in significantly reducing symptomatology.

Our promising and positive results are in line with the findings of previous studies on the effectiveness of TF-CBT and EMDR in young children. The two previous studies [17, 18], that, similar to the present study, also evaluated diagnostic status and comorbid problems besides PTSD symptoms, found a remission rate of 82.4% in diagnostic status after 12 sessions TF-CBT [17] and 83.3% and 77.1% after stepped-Care TF-CBT and regular TF-CBT (12 sessions) respectively [18]. Both studies also found large treatment effects on emotional and behavioral problems. Treatment effects in our EMDR study were reached in less sessions (6 sessions of 60 min) compared to the abovementioned TF-CBT studies (12 sessions of 90 min). The findings of our study are also consistent with the results of the non-controlled EMDR studies focusing on young children [19, 20], showing significant reduction of PTSD symptoms for children with single trauma in a mean number of 3 sessions of 50 min maximum [19] and 5 daily sessions of group therapy (50–60 min each) for traumatized refugee preschoolers [20].

The meta-analysis of the individual effects on the daily measures of the two idiosyncratic main PTSD symptoms yielded statistically significant reductions in the treatment phase compared to the baseline phase and in the follow-up phase compared to the baseline phase. However, the effects of the daily measures in the present study were not statistically significant on the individual level, which may be understandable since the power of single cases with an A–B phase design is low [21] and the variability in ratings on the daily measures was high for most participants, in all treatment phases. A possible explanation for this unexpected high variability in ratings can be found in the type of PTSD symptoms that were selected by the parents. Most parents indicated angry outbursts and sleep disturbance as the main PTSD symptoms. This is perhaps understandable as these symptoms tend to interfere most in daily life. However, in particular these two symptoms are also common reactions to minor stressors in young children, which is understood to be part of normal emotional development [44]. Therefore, some variability in these symptoms is to be expected. A diary with a broader range of PTSD symptoms or a short PTSD questionnaire might be less susceptible to normal variations in emotional states in young children.

We found stronger reductions in emotional and behavioral problems on the TSCYC questionnaire than the SDQ, which is consistent with previous findings. The SDQ has been found to have limited sensitivity to change after treatment. For instance, Wolpert et al. [45] examined the RCI on the SDQ for a large group of children and adolescents ($N = 9764$) after treatment of various mental health problems. Only 16.5% of the children were found to show a reliable reduction post-treatment in total difficulties scores. This is much lower than in the present study, where we found reliable reduction in 37.5% of the tested participants

post-treatment and in 50% of the tested participants at 3-month follow-up.

The present study benefitted from several strengths. First, the use of a multi method and multi informant approach with a diagnostic interview, standardized questionnaires, and daily idiosyncratic measures of the two main PTSD symptoms throughout the different phases of the study. This provided a detailed insight in the course of the symptoms in real-life. Secondly, the multiple baseline experimental design with nine replications allowed the use of advanced statistical analyses of single case data and enabled us to test whether change in symptoms was related to the onset of the treatment phase. Finally, the treatment was manualized and therapists were supervised to optimize treatment adherence.

There were also limitations. As there was no active control condition, we did not control for potential placebo effects. The non-concurrent design limits the inferences that can be made based on our findings, as it does not control for history as a threat to validity. Future studies could use a partially non-concurrent multiple baseline design (e.g. have two participants start the procedure at the same time) to control for historical factors. Obviously, caregivers were not blinded to the treatment phase their child was in, neither were the independent assessors who evaluated the diagnostic status. Additionally, the small sample-size that is inherent of the case series design limits the generalizability of our findings. However, the participants were a heterogeneous group with different types of chronic traumatic experiences. Further research is warranted. In the present study, we did not focus on children younger than four years old, for whom EMDR may also be well suited [46]. We suggest replication of this study with young children aged 1.5–4 years old, followed by a randomized controlled trial into the effectiveness of EMDR in a large group of children aged 1.5–8 years old with PTSD compared to wait-list. While all children completed treatment, three caregivers failed to complete all measurements. A suggestion for researchers to improve response rates post-treatment and at follow-up is to combine the measurements with a brief face to face meeting with the therapist. Future research could also examine if children with certain characteristics or types of trauma can benefit more from EMDR than others.

In conclusion, this study shows that EMDR is a feasible, effective and brief treatment of pediatric PTSD in young children aged 4–8 years, who experienced multiple traumatic events. Remission rate of PTSD status was high, and we found strong declines of PTSD symptoms and trauma-related emotional and behavioral problems. These results are promising, as early and effective treatment is essential in order to divert the invasive acute and long-term effects of PTSD in this high-risk group.

Summary

To reduce the acute and long-term effects of trauma, early and effective treatment is necessary. Effective treatment of PTSD and other trauma-related symptoms in young children (< 8 years old) has been a largely neglected area of research until recently. EMDR therapy is a brief, trauma-focused treatment for PTSD, with a substantial evidence base for older children and adolescents. In the present study we aimed to provide preliminary evidence of EMDR as treatment for young children. We studied nine children, aged 4 to 8 years old, who were exposed to multiple or chronic traumatic events and diagnosed with a DSM-5 diagnosis of PTSD, established with the DIPA. A non-concurrent multiple baseline experimental design was used combined with standardized measures pre- and post-treatment and at a 3-month follow-up. Participants received six 1-h sessions of EMDR. There was neither treatment dropout nor any adverse events. Results post-treatment showed that EMDR was effective in reaching diagnostic remission of PTSD in all participants except one and in decreasing severity of PTSD symptoms (meta-analysis daily measures $p = 0.03$ and reliable changes on PTSD scale TSCYC) and emotional and behavioral problems (reliable changes on emotional and behavioral scales TSCYC). All gains were maintained at 3-month follow-up. EMDR appears an effective treatment for PTSD in young children. Further research is warranted, including randomized controlled trials.

Appendix

See Tables 4 and 5.

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Declarations

Conflict of interest C.de.R. receives income for training postdoctoral professionals in EMDR. The other authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional and National Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Medical Ethics Committee of the Erasmus Medical Centre NL66334.078.18.

Table 4 Trauma Symptom Checklist for Young Children (TSCYC), T-scores determined pre-treatment, post-treatment and at 3-month follow-up, and reliable change indices (RCI), per participant

Participant	T pre	T post	T FU	RCI post	RCI FU
PTSD total					
1	76	61[a]	–	−5.05[b]	–
2	84	61[a]	64[a]	−7.74[b]	−6.73[b]
3	103	83	80	−6.73[b]	−7.74[b]
4	96	79	75	−5.72[b]	−7.07[b]
5	80	50[a]	50[a]	−10.1[b]	−10.1[b]
6	104	79	83	−8.42[b]	−7.07[b]
7	107	–	–	–	–
8	90	62[a]	–	−9.43[b]	–
9	100	70	44[a]	−10.1[b]	−18.18[b]
Mean (SD)	93.33 (11.3)	68.12 (11.52)	66.0 (16.19)		
Dissociation					
1	56[a]	46[a]	–	−6.13[b]	–
2	55[a]	49[a]	42[a]	−3.68[b]	−8[b]
3	82	82	85	0	1.84
4	59[a]	43[a]	43[a]	−9.81[b]	−9.81[b]
5	79	52[a]	45[a]	−16.56[b]	−20.86[b]
6	59[a]	52[a]	49[a]	−4.29[b]	−6.13[b]
7	76	–	–	–	–
8	61[a]	58[a]		−1.84	–
9	100	43[a]	43[a]	−34.97[b]	−34.97[b]
Mean (SD)	69.67 (15.43)	53.13 (11.9)	51.17 (16.76)		
Depression					
1	56[a]	52[a]	–	−2.8[b]	–
2	47[a]	46[a]	43[a]	−0.7	−2.8[b]
3	83	72	65	−7.69[b]	−12.59[b]
4	73	51[a]	54[a]	−15.38[b]	−13.29[b]
5	76	43[a]	43[a]	−23.08[b]	−23.08[b]
6	73	58[a]	69	−10.49[b]	−2.8[b]
7	77	–	–	–	–
8	76	62[a]	–	−9.79[b]	–
9	107	47[a]	43[a]	−40.56[b]	−44.76[b]
Mean (SD)	74.22 (16.74)	53.88 (9.64)	52.83 (11.84)		
Anxiety					
1	90	82	–	−6.59[b]	–
2	84	77	74	−4.23[b]	−5.49[b]
3	90	80	80	−5.49[b]	−5.49[b]
4	93	65	65	−15.4[b]	−15.4[b]
5	80	55[a]	55[a]	−13.74[b]	−13.74[b]
6	97	76	79	−11.54[b]	−9.89[b]
7	93	–	–	–	–
8	71	58[a]	–	−7.14[b]	–
9	107	72	45[a]	−19.23[b]	−34.07[b]
Mean (SD)	89.44 (10.31)	70.63 (10.17)	66.33 (14.08)		
Anger					
1	86	71	–	−8.98[b]	–
2	49[a]	41[a]	41[a]	−4.79[b]	−4.79[b]
3	85	55[a]	55[a]	−17.96[b]	−17.96[b]
4	49[a]	49[a]	45[a]	0	−2.4[b]
5	66	52[a]	55[a]	−8.38[b]	−6.59[b]
6	65	59[a]	59[a]	−3.59[b]	−3.59[b]

Table 4 (continued)

Participant	T pre	T post	T FU	RCI post	RCI FU
7	88	–	–	–	–
8	96	88		−3.59[b]	–
9	96	49[a]	45[a]	−28.14[b]	−30.54[b]
Mean (SD)	75.56 (18.72)	58 (13.99)	50 (7.24)		
Sexual problems					
1	55[a]	51[a]	–	−4	–
2	46[a]	46[a]	46[a]	0	0
3	46[a]	46[a]	46[a]	0	0
4	47[a]	47[a]	47[a]	0	0
5	46[a]	46[a]	46[a]	0	0
6	47[a]	47[a]	47[a]	0	0
7	51[a]	–	–	–	–
8	86	63[a]	–	−23	–
9	47[a]	47[a]	47[a]	0	0
Mean (SD)	53.33 (12.98)	49.12 (5.84)	46.5 (.55)		

T-scores are norm scores (*mean* 50, *SD* = 10, range = 35–110). T scores ≤ 64 normal, 65 ≥ 69 possible problematic, ≥ 70 clinically significant

[a]T score in normal range

[b]RCI ≥ 1.96

Table 5 Strength and Difficulties Questionnaire (SDQ): Total Difficulty Score determined at pre-treatment, post-treatment and 3-month follow-up and reliable change indices (RCI) at post-treatment and 3-month follow-up, compared to pre-treatment, per participant

Participant	T pre	T post	T FU	RCI post	RCI FU
1	24	21	–	−0.92	–
2	18	12[a]	12[a]	−1.84	−1.84
3	18	15	19	−0.92	0.3
4	19	11[a]	15	−2.45[b]	−1.23
5	27	15	16	−3.68[b]	−3.37[b]
6	25	22	18	−0.92	−2.15[b]
7	25	–	–	–	–
8	24	19	–	−1.53	–
9	26	17	10[a]	−2.76[b]	−4.91[b]
Mean (SD)	22.9 (3.6)	16.5 (4)	15 (3.5)		

Total Difficulties Scores range from 0 to 40. Normal range: 0–13, borderline: 14–16, abnormal: 17–40

[a]Total Difficulties Score in normal range

[b]RCI ≥ 1.96

Informed Consent Informed consent was obtained from all individual caregivers included in this study.

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