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CLINICAL RESEARCH ARTICLE

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Mediators of change in a condensed online exposure-based intervention provided soon after trauma: insights from a randomised controlled trial

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ABSTRACT

Background: The active mechanisms of change are unclear in early-provided exposure-based interventions for psychological trauma. This study aimed to address this gap by analysing weekly data from a randomised trial involving a 3-week therapist-guided online intervention based on prolonged exposure compared to a waiting-list control group.

Method: The objective was to investigate whether changes in each of the four subscales of the Posttraumatic Stress Disorder Checklist, fifth version (PCL-5; i.e. intrusions, avoidance behaviours, negative alternations in cognitions and hyperarousal) during the three-week intervention period mediated subsequent improvements in other post-traumatic stress symptoms at the controlled 1-month follow-up. We included baseline levels of both the mediator and the outcome as well as changes in the outcome from baseline to week 3 as covariates in a mediation model.

Results: The results showed that reductions in avoidance during the intervention period mediated reduced symptom levels of intrusions, negative alternations in cognitions, and hyperarousal at week 7 (z-scores of indirect effect estimates = −0.12 to −0.07). No other PCL-5 subscales were found to be mediators of change.

Conclusions: The results from this study highlight the importance of addressing avoidance behaviours in online exposure-based interventions provided in the early aftermath of trauma. Sensitivity analysis showed that the mediation effects were sensitive to assumptions related to mediator-outcome confounders, which could be considered a study limitation.

Trial registration: ClinicalTrials.gov identifier: NCT03850639.

Mediadores del cambio en una intervención abreviada en línea, basada en exposición, administrada poco después del trauma: perspectivas de un ensayo controlado aleatorizado

Antecedentes: Los mecanismos activos de cambio no están claros en las intervenciones basadas en la exposición proporcionadas tempranamente para el trauma psicológico. Este estudio tuvo como objetivo abordar esta brecha analizando datos semanales de un ensayo aleatorizado que involucró una intervención en línea de 3 semanas guiada por un terapeuta basada en la exposición prolongada, comparada con un grupo de control en lista de espera.

Método: El objetivo fue investigar si los cambios en cada una de las cuatro subescalas de la Lista de Verificación del Trastorno por Estrés Postraumático, quinta versión (PCL-5); es decir, intrusiones, conductas de evitación, alteraciones negativas en cogniciones e hiperactivación durante el período de intervención de tres semanas, mediaron mejoras subsecuentes en otros síntomas de estrés postraumático en el seguimiento controlado de 1 mes. Incluimos los niveles iniciales tanto del mediador como del resultado, así como los cambios en el resultado desde el inicio hasta la semana 3 como covariables en un modelo de mediación.

Resultados: Los resultados mostraron que las reducciones en la evitación durante el período de intervención mediaron la reducción de los niveles de síntomas de intrusiones, alteraciones negativas en las cogniciones e hiperactivación en la semana 7 (puntuaciones z de estimaciones de efectos indirectos = −0.12 a −0.07). No se encontraron otras subescalas del PCL-5 como mediadoras del cambio.

Conclusiones: Los resultados de este estudio destacan la importancia de abordar las conductas de evitación en las intervenciones en línea basadas en la exposición proporcionadas en las primeras etapas después del trauma. El análisis de sensibilidad mostró que los efectos de mediación fueron sensibles a los supuestos relacionados con los factores de confusión mediador-resultado, lo que podría considerarse una limitación del estudio.

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Post-traumatic stress; trauma; early intervention; Internet; prolonged exposure; mediation

PALABRAS CLAVE

Estrés postraumático; trauma; mediación; exposición prolongada; internet; intervención temprana

HIGHLIGHTS

- The underlying mechanism of change in early-provided exposure-based interventions for psychological trauma was examined.
- Reductions in avoidance behaviours during the 3-week online exposure-based intervention mediated improvements in symptoms of intrusions, negative alterations in cognitions/mood, and hyperarousal 1-month follow-up after its completion.
- The study highlights the significance of addressing avoidance behaviours in early online exposure-based trauma interventions while acknowledging limitations related to mediator-outcome confounders.

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1. Introduction

The World Health Organization identifies trauma as a major global public health problem with a lifetime prevalence as high as 70% (Koenen et al., 2017). Trauma can have a profoundly negative impact on mental health and will for 5–6% of afflicted individuals lead to Post-Traumatic Stress Disorder (PTSD) which is characterised by recurrent intrusions, avoidance, negative alterations in cognitions and mood, and hyperarousal (Koenen et al., 2017). PTSD is a debilitating mental disorder in itself and is associated with substantial psychiatric and somatic comorbidity and impairment (Kessler et al., 1995; McFarlane et al., 1994; Song et al., 2018).

Prolonged exposure (PE) is an effective evidence-based treatment for PTSD that confers a positive treatment response in a majority of patients both at short- and long-term follow-up (Hamblen et al., 2019; Lee et al., 2016; Mavranezouli et al., 2020; Watts et al., 2013). PE is based on emotional processing theory, and the core treatment component, exposure to trauma-related cues, is thought to facilitate emotional processing through refraining from avoidance behaviours (Foa & Kozak, 1986; Foa & Mclean, 2016). Evidence supports emotional processing being influenced by factors such as emotional engagement during exposure, between-session decreased emotional responding, and cognitive change. Notably, in-session decreased emotional responding appears to be less pronounced as a contributing factor to treatment efficacy. Another crucial element implicated in the reduction of PTSD symptoms is the modification of negative cognitions about oneself and the world that commonly are associated with the disorder (Alpert et al., 2023; Cooper et al., 2017; Kooistra et al., 2023; Kumpula et al., 2017; McLean et al., 2015; Zalta et al., 2014).

One way to increase the outreach of effective treatments could be to deliver PE in the early aftermath of trauma. One trial by Rothbaum et al. (2012) showed that a modified PE intervention that was provided in an emergency department by a face-to-face therapist within hours after the traumatic event was effective in reducing trauma symptoms. A recent trial by Maples-Keller et al. (2020) tested the same type of treatment as Rothbaum et al. but were not able to replicate these findings. These subsequent null results may however be due to low power (Maples-Keller et al., 2020). Our research group has recently developed a condensed internet-delivered prolonged exposure intervention (CIPE) specifically tailored for individuals who have recently been exposed to a traumatic event within the last two months. As in the full PE treatment outline for PTSD, the core focus of the CIPE intervention is to reduce avoidance and facilitate emotional processing of the traumatic memory. This is done through written material encouraging the participant to engage in imaginal and in vivo exposure during the brief intervention period of 3 weeks. Following a feasibility trial ($N = 32$; Bragesjö et al., 2021c) with additional qualitative interviews ($N = 11$; Bragesjö et al., 2021a), a randomised efficacy trial ($N = 102$; Bragesjö et al., 2021b) showed that CIPE was more effective than a waiting-list control group in reducing trauma symptoms (bootstrapped $d = 0.70$–0.83) measured with the Posttraumatic Stress Disorder Checklist, fifth version (PCL-5). One next step could be to investigate which factors drive the effects of this intervention. Given the weak evidence base of early interventions for trauma (Hermosilla et al., 2023), more research is needed to investigate potential mechanisms of change in early-provided PE. Greater knowledge about mechanisms of change is essential, as these investigations have the potential to offer guidance to clinicians and researchers on optimising treatment compliance, improving implementation, and minimising attrition, as highlighted by Kazdin (2007).

This current study used weekly data from our recent randomised trial and investigated putative mediators of change during the CIPE intervention. We define mediators of change as interceding variables that statistically account for the relationship between the intervention and outcome. The aim of the study was to explore whether reductions on any subscale on the PCL-5 (i.e. intrusions, avoidance behaviours, negative alternations in cognitions and mood, and hyperarousal) during the 3-week intervention period mediated symptom levels on the other subscales at the controlled follow-up at 7 weeks after randomisation.

2. Method

2.1 Design

The current study used weekly gathered data from a single site, randomised controlled trial ($N = 102$) that compared CIPE to a waiting list control condition from October 2019 to June 2020 to investigate potential mediators that may account for the observed changes in outcomes over the course of the intervention. See original publication for more details on trial methods (Bragesjö et al., 2021b). The trial was preregistered on ClinicalTrials.gov before any participant was enrolled (registration ID: NCT03850639). The study was approved by the National Ethical Review Board in Sweden (registration ID: 2019-04413). Participants were consecutively randomised after the provision of written informed consent using a true random algorithm (www.random.org).

2.2 Procedures

Participants were recruited nationwide in Sweden using self-referral to the study website that was set up solely for the purpose. After an online screening using self-rated measures, a clinical psychologist assessed eligibility by phone. The primary eligibility criteria were the following: Swedish residents exposed to a traumatic event according to criterion A for PTSD in the fifth version of the Diagnostic and Statistical Manual of Mental Disorders within two months prior to inclusion (i.e. exposed to actual or threatened death, serious injury, or sexual violence American Psychiatric Association, 2013) with at least a total score of ≥ 10 points on the PCL-5.

Based on the scoring interpretation guidelines provided by the National Center for PTSD for the PCL-5, a reduction of at least 10 points indicates a clinically significant improvement. Our aim was to ensure that each participant could experience this level of benefit from the treatment (Weathers et al., 2013).

Exclusion criteria were the following: (a) other serious psychiatric comorbidities as the primary concern (e.g. ongoing substance abuse, untreated bipolar disorder, psychotic symptoms, severe depression, or high suicide risk); (b) currently receiving CBT for trauma-related distress; and (c) ongoing trauma-related threat (e.g. living with a violent spouse). Participants on psychotropic medication had to report a stable dose for two weeks prior to inclusion in the study.

The final sample included 102 participants, of which the majority were women and approximately half had a college or university degree. The mean age was 41. Approximately one-third were on sick leave. The most common index traumas were exposure to interpersonal violence (28%), death (25%), rape (16%) and motor vehicle accidents (11%). The participants' characteristics are presented in Table 1.

Table 1. Demographics.

Baseline characteristics		CIPE $^{(N=51)}$	WL $^{(N=51)}$
Gender, *n (%)*	Women	45 (88%)	39 (76%)
	Men	6 (12%)	12 (24%)
Age	Mean *(SD)*	44.7 (17)	36.7 (13.4)
	Range	18–82	18–75
Highest education, *n (%)*	College/university	30 (57%)	25 (47%)
Occupational status, *n (%)*	Working full time	15 (29%)	20 (39%)
	On sick leave	17 (33%)	15 (29%)
Psychiatric diagnoses according to the MINI, *n (%)*	Any	35 (68%)	38 (74%)
Prior exposure to trauma, *n (%)*	Previous exposure to trauma	37 (72%)	39 (76%)
	None	14 (27%)	12 (24%)
Type of trauma, *n (%)*	Rape/interpersonal violence	27 (53%)	28 (55%)
	Nonintentional	24 (47%)	23 (45%)
Days since exposure to index trauma, mean (SD)	Mean (*SD*)	36.3 (19)	35.4 (17.11)
	Range	6–65	4–62

Abbreviations: CIPE, Condensed Internet-Delivered Prolonged Exposure; WL; waiting list; MINI, Mini International Neuropsychiatric Interview.

2.3 Intervention

CIPE is a digital three-week therapist-guided intervention that is based on the full Prolonged Exposure (PE) protocol (Foa et al., 2019) but is condensed and shortened to fit as an early intervention. It comprises four treatment modules that participants sequentially gain access to after completing homework exercises. The therapist provides support by answering questions, providing emotional and practical support and encouraging the progress made through an integrated e-mail function in the online platform. The first module contains psychoeducation about common reactions after exposure to psychological trauma alongside controlled breathing exercises as a way for the participant to deal with general stress. In the second module, the participant is provided with a rationale for imaginal exposure, including detailed instructions on how to revisit and recount the memory of the traumatic event and achieve emotional processing. In module 3, participants are encouraged to approach the most distressing hot spot of their traumatic memory through imaginal exposure. Module 3 also encourages the participant to approach situations that are perceived as dangerous or triggering trauma-related distress but are objectively safe. The last module (4) contains a relapse-prevention plan. The intervention is elaborated in more depth in a previous publication (Bragesjö et al., 2021b) and in supplement 1 together with a summary of the findings.

2.4 Waiting-list control group

Half of the sample was randomised to a waiting-list control group to control for spontaneous fluctuations in trauma symptoms. These participants were informed that they would receive delayed intervention after 7 weeks and were given a telephone number to study personnel in case of worsening symptoms.

2.5 Measures

Both mediator and outcome were measured using the PCL-5, which was administered each week during the controlled study period of 7 weeks. The PCL-5 assesses the 20 PTSD symptoms as outlined in the DSM-5 on a 4-point scale, creating a possible total symptom severity score of 0-80, with higher scores indicating greater severity (Blevins et al., 2015). The subscales of the PCL-5 are (a) Re-experiencing (e.g. recurrent, involuntary, distressing memories of the traumatic event, nightmares, items 1-5) [hereafter labelled 'intrusions'] (b) avoidance behaviours (e.g. avoids internal or external reminders of the trauma, items 6-7), (c) negative alterations in cognitions and mood (e.g. persistent and exaggerated negative beliefs or expectations about oneself, others, or the world, persistent negative

emotional state, items 8-14) [hereafter labelled 'cognitions'] and (d) hyperarousal (e.g. hypervigilance, exaggerated startle response, items 15-20). The original version of the PCL-5 has a recall period of one month; this was changed to one week in the current trial to better fit the study outline with weekly measurements.

2.6 Statistical analyses

Given the small amount of previous research in this research field, we chose an exploratory approach in which change during the 3-week intervention period in the four putative mediators (change in intrusions, avoidance behaviours, cognitions, and hyperarousal subscales on the PCL-5) were analysed separately on each of the other subscales at week 7. The statistical framework was as follows: We first constructed an individual slope that represented a change from week 0 to 3 on each subscale on the PCL-5 in mixed regression models with random intercepts and slopes. All subscale scores were converted to z-scores. Next, we repeated the analysis but included all 7 measurement points to estimate week 7 scores on the PCL-5. In a third step, three regression models were run for each PCL-5 subscale in which the estimated 7-week scores on the other PCL-5 subscales were regressed on the estimated slope for week 0–3 on the mediators in a counterfactual mediation model in Stata 16.1 (*medeff* command) (Hicks & Tingley, 2011; Imai et al., 2010a). The models also included other covariates: change in the outcome subscale from week 0 to week 3, and the intercepts on both the mediator and the outcome subscale. Direct, indirect, and total effects were estimated for each outcome (95% confidence intervals were constructed using 1000 simulations; Hicks & Tingley, 2011; Imai et al., 2010a). Mediation, or indirect, effects were evaluated as statistically significant if the 95% confidence intervals did not cross zero. To test potential mediator-outcome confounding factors, also known as sequential ignorability, significant mediators were further tested for robustness in sensitivity analyses. In these analyses, we fixed the residual correlation between the mediator and the outcome from $r = -.9$ to.9 using the *medsens* command in Stata 16.1 (Hicks & Tingley, 2011; Imai et al., 2010a). A mixed effects regression framework overcomes the limitation of excluding subjects with missing data by leveraging all available information from each participant and estimating specific missing data points. Such frameworks, including mixed-effects regression and related methods like growth curve modelling, are widely regarded as the current gold standard in clinical trial research due to their robustness in handling missing data and other notable advantages (Gueorguieva, & Krystal, 2004; Quené & van den Bergh, 2004).

3. Results

The CIPE-group had significantly larger reductions on all subscales on the PCL-5 compared to the control group in the main mixed effects model ($\beta = -.11$ to -0.06, $Z = -5.12$ to -3.31, $p < .01$ to $p < .001$). Mean scores on each subscale of the PCL-5 are shown in Table 2. The scores for the intervention group on each subscale showed a monotonic decreasing pattern except from weeks 6 to 7, when there were slight increases in all subscales. The scores in the waiting list group also decreased, although slightly and with less consistency as the intervention group. Zero-order correlations between the different subscales are provided in the online supplement (Tables e1 and e2).

Table 3 displays the total, direct, and indirect effects of the PCL-5 subscales when all covariates were included in the model. Change on the avoidance subscale from week 0 to week 3 mediated outcome on all other PCL-5 subscales at week 7 while controlling for the mediator and outcome intercepts and the change in the outcome from week 0 to week 3. As shown in Figure 1, the CIPE intervention led to significantly larger reductions in the avoidance subscale from weeks 0 to 3 than in the waiting-list control group. Additionally, reductions in avoidance were in turn significantly associated with lower scores at week 7 on the other outcomes. Changes in neither intrusion, cognitions nor hyperarousal symptoms had any mediating (indirect) effects on the other subscales (Table 3).

Table 2. Mean scores on the PCL-5 subscales.

	CIPE					Waiting list				
Week	*n*	Intrusions *m* (SD)	Avoidance *m* (SD)	Cognitions *m* (SD)	Hyperarousal *m* (SD)	*n*	Intrusions *m* (SD)	Avoidance *m* (SD)	Cognitions *m* (SD)	Hyperarousal *m* (SD)
0	51	11.67 (3.87)	5.16 (2.14)	12.59 (6.25)	11.59 (4.92)	51	12.63 (3.76)	5.69 (2.04)	13.57 (5.39)	13.31 (4.72)
1	44	10.00 (4.16)	3.93 (2.15)	11.80 (5.78)	10.84 (5.74)	47	11.43 (4.26)	5.53 (2.15)	11.81 (4.98)	12.21 (4.30)
2	43	8.09 (4.71)	3.09 (2.39)	9.00 (5.81)	9.30 (5.41)	49	10.96 (4.30)	5.49 (2.20)	12.37 (5.22)	12.41 (5.57)
3	44	6.98 (5.26)	2.55 (2.16)	7.59 (6.36)	8.14 (5.98)	50	10.52 (5.04)	5.14 (2.29)	12.06 (5.35)	11.94 (5.21)
4	39	6.10 (5.24)	2.11 (1.90)	7.08 (6.52)	7.34 (5.64)	46	10.26 (5.23)	4.63 (2.53)	11.67 (5.55)	11.35 (5.34)
5	36	5.28 (4.61)	1.92 (2.01)	5.76 (5.54)	6.84 (5.46)	45	9.51 (5.26)	4.78 (2.38)	11.02 (5.81)	10.71 (5.77)
6	34	4.15 (4.67)	1.74 (2.06)	5.35 (5.78)	5.91 (5.08)	45	9.62 (5.10)	5.11 (2.46)	11.16 (5.99)	11.04 (5.93)
7	43	5.67 (5.39)	2.16 (2.32)	6.49 (6.47)	7.05 (6.31)	48	9.94 (5.67)	5.04 (2.48)	12.02 (5.80)	11.46 (6.22)

Abbreviations: CIPE, Condensed Internet-Delivered Prolonged Exposure.

Table 3. Total, direct, and indirect effects of changes in Posttraumatic Stress Disorder symptom clusters during the 3-week early intervention on other symptom clusters at the 7-week assessment.

		Outcome at week 7			
Mediator	Effect	Intrusions β (95% CI)	Avoidance β (95% CI)	Cognitions β (95% CI)	Hyperarousal β (95% CI)
Intrusions	Total	—	**−0.22 (−0.45, −0.001)**	−0.09 (−0.25, 0.08)	−0.09 (−0.29, 0.12)
	Direct	—	**−0.23 (−0.45, − 0.01)**	−0.07 (−0.23, 0.08)	−0.05 (−0.25, 0.14)
	Indirect	—	0.003 (−0.03, 0.04)	−0.01 (−0.06, 0.01)	−0.03 (−0.10, 0.02)
Avoidance	Total	−0.22 (−0.47, 0.03)	—	−0.09 (−0.25, 0.08)	−0.09 (−0.29, 0.13)
	Direct	−0.10 (−0.34, 0.15)	—	−0.02 (−0.18, 0.15)	0.03 (−0.18, 0.24)
	Indirect	**−0.12 (−0.25, −0.03)**	—	**−0.07 (−0.16, −0.01)**	**−0.12 (−0.24, −0.03)**
Cognitions	Total	−0.23 (−0.47, 0.01)	**−0.23 (−0.46, −0.002)**	—	−0.09 (−0.30, 0.12)
	Direct	−0.18 (−0.41, 0.05)	−0.22 (−0.44, 0.005)	—	−0.05 (−0.25, 0.15)
	Indirect	−0.05 (−0.14, 0.01)	−0.01 (−0.06, 0.03)	—	−0.04 (−0.12, 0.01)
Hyperarousal	Total	−0.22 (−0.47, 0.01)	**−0.22 (−0.45, −0.002)**	−0.09 (−0.25, 0.07)	—
	Direct	−0.18 (−0.39, 0.03)	**−0.23 (−0.44, −0.02)**	−0.08 (−0.23, 0.08)	—
	Indirect	−0.04 (−0.14, 0.08)	0.008 (−0.06, 0.08)	−0.006 (−0.04, 0.02)	—

Note. The effects were estimated in a counterfactual mediation model controlling for baseline levels of symptoms of outcome and mediator and changes in the outcome variables from week 0 to 3. Statistically significant effects are denoted in boldface.

Figure 2 shows the sensitivity analysis where the x-axis represents the different values of fixed residual correlations between the mediator and the outcome (ranging from −.9 to.9). The y-axis represents the indirect effects from the mediation model. The point at which the 95% confidence interval crossed the y-axis was $r = 0.0–0.1$, indicating that the indirect effects were sensitive to potential unmeasured confounders.

4. Discussion

This study aimed to investigate potential mediators of change in an online intervention based on Prolonged Exposure (PE) for recently traumatised individuals. Delivering PE shortly after trauma has generated significant interest because of its potential to improve access to effective treatments. However, to fully maximise its benefits, it is crucial to gain a deeper understanding of the underlying mechanisms that drive therapeutic change in this early stage of intervention. With the evidence base surrounding early interventions for trauma being limited, there is a critical need for further research to elucidate the mechanisms of change inherent in early-provided PE. Enhanced comprehension of these mechanisms carries significant implications, providing invaluable insights for clinicians and researchers to optimise treatment compliance, refine implementation strategies, and mitigate attrition rates, as underscored by Kazdin (2007). This study aims to address this knowledge gap by investigating potential mediators of change within the context of early-delivered PE.

In summary, the most consistent finding was that reductions in self-reported avoidance symptoms during the 3-week intervention mediated improvements across all other symptom clusters by the week 7 follow-up, even when accounting for baseline levels and symptom changes from week 0 to week 3. However, the sensitivity analysis revealed that these mediation effects would not reach statistical significance if the residual correlation between the mediator and outcome exceeded $r = 0.1$, indicating that the model is sensitive to potential confounders.

Our findings emphasise the critical role of avoidance behaviours as a key mediator of change in early interventions, which aligns with broader PTSD research highlighting avoidance as a central treatment target (Kazdin, 2007). However, it is essential to acknowledge that the mechanisms driving change in early interventions may differ from those in established treatments for chronic psychopathology, where cognitive and behavioural patterns are more ingrained (Kazdin, 2007; Wampold et al., 2010). While established therapies often focus on long-term cognitive restructuring and emotional processing, early interventions like CIPE may prioritise immediate behavioural targets, such as reducing avoidance, before maintenance cycles become entrenched. This study sheds light on how early reductions in avoidance can lead to broader improvements in symptom clusters before more fixed psychopathological patterns fully develop.

It has long been theorised that relying too heavily on avoidance strategies can disrupt the natural recovery process after a traumatic event (Bisson, 2009). Consistent with this, several studies have shown that excessive use of avoidance after trauma is predictive of the development and chronicity of PTSD symptoms (Gil, 2005; Harvey & Bryant, 1998; Kumpula et al., 2011; North et al., 1999; Pineles et al., 2011). Additionally, a higher degree of avoidance has been associated with poorer long-term outcomes in CBT for PTSD (Tarrier & Sommerfield, 2004). In this study, the initial reduction in avoidance behaviours was found to mediate improvements in other PTSD symptom clusters, but the reverse was not observed. The mediation analysis also showed that decreased avoidance was associated with lower levels of other trauma-related symptoms.

However, it is important to consider that participants in a previous qualitative study by our research group (Bragesjö et al., 2021a) reported taking a flexible

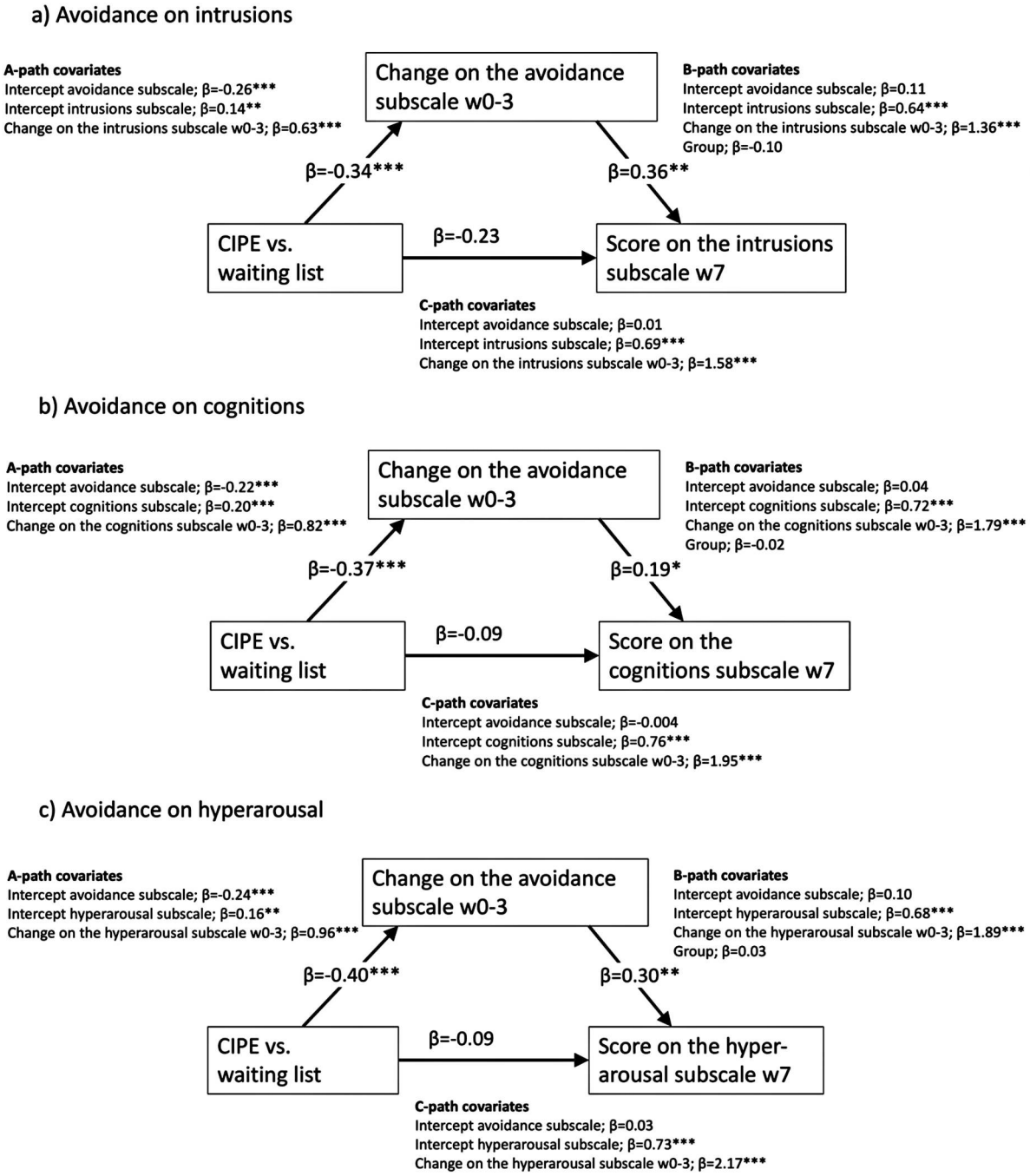

Figure 1. a–c. Change in avoidance at week 0–3 (w0-3) as mediator for other Posttraumatic Stress Disorder symptom clusters at post-assessment (w7) in Condensed Internet-Delivered Prolonged Exposure (CIPE). *$p < .05$; **$p < .01$; ***$p < .001$; $p > .05$ for all other regression coefficients.

approach to exposure exercises. For example, many described engaging in spontaneous exposure when it occurred naturally in everyday life, rather than strictly following a structured exposure hierarchy with planned sessions. The mediating role of reduced avoidance observed in this study should therefore be viewed in the context of this individualised, flexible approach to exposure.

Consequently, it is possible that early changes in avoidance will facilitate improvements in negative cognitions at week 7, which, in turn, have additional cascade effects related to long-term functional outcomes. Future studies should investigate this pathway of change more closely, being mindful of the possibility that the mediating effects during behavioural interventions may be different between early interventions and later treatment (Kooistra et al., 2023; Kumpula et al., 2017; McLean et al., 2015; Zalta et al., 2014).

Another interesting finding in this study was that neither the intrusions, cognitions nor hyperarousal symptom clusters had any mediating effect on any outcome variable. This is clinically important, as it indicates that avoidance is a specific mediator of change in this type of intervention. A next step could be to investigate whether avoidance as an early mediator of change is specifically related to PE or

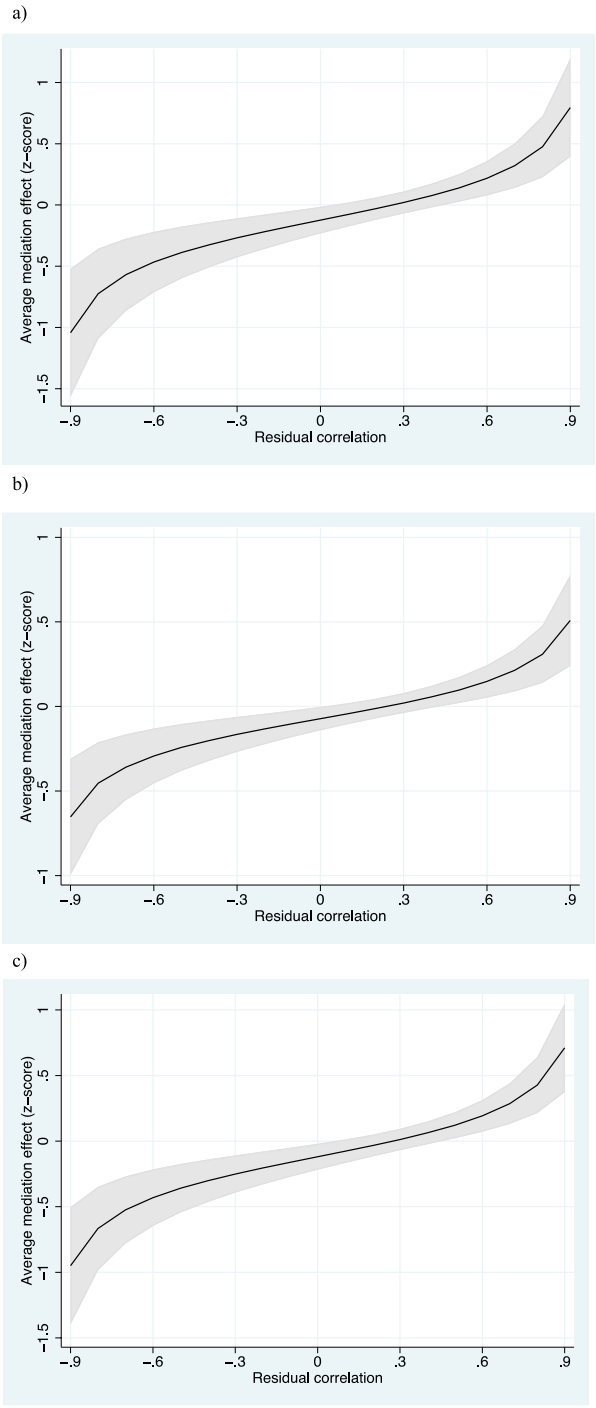

Figure 2. a-c. Sensitivity analyses. (2a) Avoidance on intrusions, (2b) Avoidance on cognitions, (2c) Avoidance on hyperarousal.

whether the results are generalisable to other types of interventions. One idea could be to compare early-provided PE with cognitive processing therapy and investigate if the cognitive intervention leads to an earlier change in negative cognitions compared to PE and if this, in turn, leads to differential mediation. In addition, it is currently unclear whether baseline characteristics (e.g. trauma type) could moderate this mediation process.

Strengths of the current study include the relatively large sample size, the time-lagged design and the controlled follow-up assessment at 7 weeks. Furthermore, we included baseline values of both the mediator of change, the outcome, and initial improvements in the outcome variables from weeks 0 to 3 in the mediation model. We also conducted a comprehensive sensitivity analysis and gradually tested the assumption of unknown mediator-outcome confounders. This type of analysis is essential to examine the robustness of the results and the possible existence of unmeasured confounders (Imai et al., 2010b) but is, to our knowledge, rarely conducted in psychological treatment trials.

This study also has several limitations. One major limitation was the use of an exploratory approach where several different mediators were tested without any prespecified hypotheses. This way of analysing data can increase the risk of type-1 errors, and the results should therefore be regarded as preliminary. Another limitation was that both mediators and outcomes were assessed with self-rated measures, and one next step could therefore be to use a more objective clinician measure such as the Clinician-Administered PTSD Scale (Weathers et al., 2018). Third, this study used an internet-delivered format to deliver the intervention. Internet-delivered interventions have a high degree of standardised structure, which may minimise the degree of therapist drift. It is therefore unclear if the results are generalisable to face-to-face therapy. Finally, the sample in this study comprised individuals with diverse trauma-type histories, which may lead to different types of mechanistic change. However, due to sample size limitations, subgroup analyses testing various forms of moderated mediation models were not feasible.

With these limitations in mind, we conclude that avoidance is a specific mediator of change in online PE for recently traumatised individuals. Large-scale trials with longer follow-ups and clinician-administered outcome measures are warranted.

Disclosure statement

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon request given that the

request complies with Swedish and EU laws regulating the protection of identifiable data.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Trial registration

ClinicalTrials.gov registration ID: NCT03850639. The trial was registered before recruitment started.

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