



Longitudinal follow-up of the randomized controlled trial of access to the trauma-focused self-management app PTSD Coach

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ABSTRACT

Apps that target posttraumatic stress are rarely evaluated and long-term examination of symptom change is rare. In a waitlist-controlled randomized controlled trial, we found that the Swedish version of the self-management app PTSD Coach confers benefits on posttraumatic stress and depressive symptoms after three months use. Here, we aimed to evaluate between-group effects on functional disability as well as within-group changes on mental health, somatic illness and functional disability after access to the Swedish PTSD Coach app during 9 months. In addition, we described negative effects, helpfulness and satisfaction with the app. Among the 179 trauma-exposed adults (92 % women) randomized to instant access or delayed access to PTSD Coach, symptoms of posttraumatic stress, depression, somatic illness and functional disability decreased and were maintained within 3 to 9 months of app access. Posttraumatic stress continued to improve during follow-up. PTSD Coach was considered slightly to moderately helpful and satisfactory and 43 % reported any negative effect related to using the app. PTSD Coach is an effective self-management intervention for trauma-related distress. Future research should investigate mechanisms of change, as well as individual characteristics that predict symptom reduction after access to PTSD Coach in order to inform clinical practice.

1. Introduction

Self-management interventions for Posttraumatic Stress Disorder (PTSD) are interventions intended to aid individuals to cope with trauma without comprehensive support from professionals. Available apps for PTSD are rarely scientifically evaluated (Anthes, 2016; Olff, 2015; Sander et al., 2020). Studies of trauma-related self-management apps have been criticized on the basis of inadequate sample size (Anthes, 2016; Wickersham et al., 2019), short scope of follow-up (Wickersham et al., 2019), and absence of monitoring of short and long-term negative effects (Linardon et al., 2019; Sander et al., 2020; Wickersham et al., 2019). Goreis et al. (2020) argue that self-management apps are unsuitable as stand-alone interventions, but may complement face-to-face care. The strength of mobile health and self-management interventions is that they can offer instantly available and clinically sound mental

health resources in any location, day and night, at low cost for users; they can offer anonymity to overcome stigma and be adapted for individual needs, such as visual and auditory impairments (Ameringen et al., 2017; Olff, 2015; Sander et al., 2020). A systematic review of five randomized controlled trial (RCT) studies that evaluated apps that target posttraumatic stress found that the interventions were promising, but that results regarding efficacy were inconsistent (Wickersham et al., 2019). A meta-analysis found no benefit of self-management apps over controls for posttraumatic stress, which may be an issue of power or inadequate intervention design (Linardon et al., 2019). A meta-analysis of six studies (mainly regarding the app PTSD Coach) found a moderate within-group effect of reduced posttraumatic stress and small effect of reduced depressive symptoms, but no between-group effect in randomized controlled trials (Goreis et al., 2020).

PTSD Coach is a psychological app intervention for managing

Abbreviations: PTSD, Posttraumatic stress disorder; PCL-5, PTSD Checklist for the DSM-5; PHQ-9, Patient Health Questionnaire, depression; PHQ-15, Patient Health Questionnaire, somatic symptoms; WHODAS, World Health Organization Disability Assessment Schedule, 12-item version.

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trauma-related distress (Hensler et al., 2022; Kuhn et al., 2014). The app is not a replacement for psychological treatment (Hallenbeck et al., 2022; Hensler et al., 2022), but can be used together with professional support or as a self-management intervention. It offers four main modules with psychological exercises for distress management (“Manage Symptoms”), self-assessment of posttraumatic stress (“Track Progress”), resources for community and clinical support (“Get Support”) and psychoeducation regarding trauma-related complications or PTSD (“Learn”, Hallenbeck et al., 2022; Kuhn et al., 2014). The Swedish PTSD Coach (Cernvall et al., 2018; Hensler et al., 2022) was based on the American original, version 2.0, which has since been updated to version 3.1 (Hallenbeck et al., 2022). The quality of PTSD Coach is rated as good, high-quality and in the upper quartile of self-management app quality (Sander et al., 2020). According to user data, 31.77 % (among users with at least two symptom self-assessments) reported clinically significant decreases in posttraumatic stress during access to PTSD Coach (Hallenbeck et al., 2022).

Prior RCT-studies of versions of PTSD Coach have followed participants during 2 to 6 months and found both negligible, small and large effects of app access (Kuhn et al., 2017; van der Meer et al., 2020; Miner et al., 2016; Possemato et al., 2016) which we speculate might be related to differences in operationalization of outcomes and sample sizes (Hensler et al., 2022). In the short term (3 months) during the RCT of the Swedish version of PTSD Coach, we found that PTSD Coach decreases trauma-related posttraumatic stress and depressive symptoms with a small between-group effect (Hensler et al., 2022). In total, 23 % of participants with immediate access to PTSD Coach who responded at the post assessment stated that they had not used PTSD Coach in the past 3 months. On average, PTSD Coach was found slightly to moderately helpful and moderately satisfactory (Hensler et al., 2022). Half of the participants (49 %) reported no negative effects related to using PTSD Coach, and no one reported dependency on the app or increased suicidality due to using PTSD Coach (Hensler et al., 2022). The most common negative effects of using PTSD Coach concerned disappointment and design limitations, e.g. unfulfilled expectations on the app (25 %), finding it demotivating (20 %), that it did not produce results (18 %), was difficult to understand (15 %), in addition to symptom-related reactions, e.g. resurfacing of unpleasant memories (13 %), increased stress (11 %) or anxiety (10 %; Hensler et al., 2022, Appendix 2).

In summary, self-management apps have the potential to offer flexible, sound trauma-focused resources, but their benefits and harms are unclear and rarely investigated with sufficient methodological consideration. Results regarding efficacy from controlled studies of PTSD Coach are inconsistent, and the long-term relationships of access to the Swedish version of PTSD Coach, symptoms and functional disability are unknown.

1.1. Aims of the study

The aim of this study was to assess uncontrolled, within-group follow-up changes in posttraumatic stress, depressive and somatic symptoms from an RCT of PTSD Coach as well as assess controlled, between-group effects of functional disability among trauma-exposed adults in Sweden (Hensler et al., 2022). Furthermore, we report the helpfulness, satisfaction and negative effects of PTSD Coach among waitlisted participants after gaining access to PTSD Coach.

2. Method

2.1. Design

This study uses a longitudinal waitlist design with follow-up assessments of symptoms and disability in two groups that received access to PTSD Coach immediately after baseline (instant access condition) or after 3 months (delayed access condition). The instant access condition had access to the app during 9 months. The delayed access condition

gained access to PTSD Coach after 3 months, and had access to the app during 6 months. See Hensler et al. (2022) for further details.

2.2. Participants

The sample comprised participants from the PTSD Coach randomized controlled trial in Sweden (Hensler et al., 2022). In short, we recruited 179 adults (men/non-binary/other = 15) who presented with at least mild posttraumatic stress, had experienced a potentially traumatic event in the past two years and had no ongoing psychotherapy. On average, participants reported moderate to high posttraumatic stress and 55 % screened positive for PTSD (Hensler et al., 2022).

2.3. Procedure

We recruited a convenience sample after gaining permission by the Ethical Review Board in Uppsala, Sweden (reference 2018/319). Data collection started May 2019 and ended May 2021. Participants were recruited through social media adverts. They completed an online screening questionnaire, provided written informed consent and were subsequently interviewed by a member of the research team over the phone to assess eligibility and clinical characteristics. Then, participants responded to online questionnaires at baseline and after 3, 6 and 9 months. Instant and delayed access conditions were randomized (1:1) after the baseline assessment. In addition, all participants responded to daily surveys regarding strategies and self-management app use during the first 21 days subsequent to the randomization, which is reported elsewhere (Hensler et al., 2021). Randomized participants were invited to all follow-up assessments regardless of whether they responded to a prior assessment. The participant received written instructions on how to download the app after randomization, after completion of the 3 month-questionnaire, or per request after the initial 3 months. In coherence with others (van der Meer et al., 2020; Miner et al., 2016) and to imitate real-world use without clinician support, we provided participants with no additional instructions on how to use PTSD Coach beyond the brief in-app text information that users receive upon first use of PTSD Coach. If participants wanted guidance, we suggested exploring the app to find content suited to their needs (Hensler et al., 2022).

2.4. Materials

Symptoms and functional disability were assessed at every time point. Posttraumatic stress was assessed with PTSD Checklist for DSM-5: PCL-5 (Blevins et al., 2015; Sveen et al., 2016), depressive symptoms with the Patient Health Questionnaire: PHQ-9 (Gilbody et al., 2007; Kroenke et al., 2001), somatic symptoms with Patient Health Questionnaire: PHQ-15 (Kroenke et al., 2002; Nordin et al., 2013) and functional disability with the World Health Organization Disability Assessment Schedule, 12-item version: WHODAS (MacLeod et al., 2016; Üstün et al., 2010a). Symptom scores were summed. The WHODAS ratings were represented as a 0–100 % score of disability by summing recoded scores $\times 100/48$ (National Board of Health and Welfare, 2022; Üstün et al., 2010b).

Quality and negative effects of PTSD Coach were measured at the 6-month assessment among delayed access participants. Scores for negative effects were recoded so that reactions that participants deemed unrelated to using PTSD Coach were given a score of 0 (“Not at all”). The perceived quality of PTSD Coach, i.e. helpfulness and overall satisfaction, was measured with the PTSD Coach Survey (Cernvall et al., 2018; Kuhn et al., 2014). The full item phrasings, number of items, points on the rating scale and anchor points of the PTSD Coach Survey are detailed in Table A5. Negative effects related to using PTSD Coach were measured with a study-specific version of the Negative Effects Questionnaire (Rozenal et al., 2019) which was adjusted for app interventions in contrast to psychological treatment. The full item phrasings, number of items, points on the rating scale and anchor points

of the study specific NEQ are detailed in Table A6. We also assessed changes in concurrent medical and psychological treatment and adherence (i.e., utilization of PTSD Coach and other self-management apps) among the delayed access participants at 3 and 6 months with single-item yes/no and free-text questions. Changes and adherence were recorded among instant access participants at the 3-month assessment and reported elsewhere (Hensler et al., 2022).

2.5. Data analysis

Full information regarding packages and version are presented in the Appendix: List A1. Data was analyzed in R (4.2.1) with the *nlme* package (version 3.1–157). We conducted within-group, intention-to-treat longitudinal regression analyses and longitudinal regression analyses with unimputed data of posttraumatic stress, depressive and somatic symptoms and functional disability \times time separately for each condition. We used the *mice* (3.14.0), *miceadds* (version 3.15–21) and *VIM* package (6.2.2) for missing data imputation (500 data sets and 10 iterations) using all available outcome data for the imputation. As only post-traumatic symptom severity at baseline predicted missing at post ($t(43.615) = -3.0785, p = 0.003$) and no other follow-ups ($p = 0.051$ to 0.07), we included baseline level of posttraumatic stress in the unimputed data models for depressive, somatic symptoms and functional disability.

Visual inspection of raw data indicated that symptom change might have plateaued following the first three months of app access. We detected a breakpoint in the instant access condition at the post assessment, with the *segmented* package (version 1.6–0). Time was coded in linear splines (Pasta, 2005) to differentiate the change in outcomes during a) the first three months of access to PTSD Coach (instant access condition: month 0–3; delayed access condition: month 3–6) and b) the follow-up phase (instant access condition: month 3–9; delayed access condition: month 6–9) in both conditions. Then, we added a spline for the delayed access condition to account for symptom change prior to access to PTSD Coach (month 0–3). Time was coded as 0 at the baseline assessment (0 months after randomization) and incremented such that one unit in time represented 3 months (Appendix: Table A1).

In addition, we made a controlled comparison of functional disability after instant, 3 months access to PTSD Coach compared to delayed access, which was analyzed in intention-to-treat and unimputed mixed-effects model of condition \times time (0 and 1).

3. Results

3.1. Sample characteristics and treatment changes

Retention rate was high: from 83.8 % at the 3-month post assessment (instant access = 82.0 %, delayed access = 85.6 %), 72.6 % at the 6-month follow-up (instant access = 73.0 %, delayed access = 72.2 %) to 65.9 % at the 9-month follow-up (instant access = 69.7 %, delayed

access = 62.2 %). The reason for attrition was not responding to assessments. Symptom severity and functional disability across assessments are presented in Table 1.

Among the delayed access participants ($n = 69$) at the 6-month follow-up, only 53.6 % reported using PTSD Coach in the past three months. Participants who reported using PTSD Coach had similar baseline levels of symptoms and disability as participants who reportedly did not use PTSD Coach (Appendix: Table A2). Two-sample *t*-tests based on non-imputed data indicated no differences in symptoms and functional disability between app users and non-users (Appendix: Table A2). Two participants reported using other self-management apps. Four participants reported new help seeking behaviors with the intention to access trauma-focused somatic or psychological treatment. Some participants initiated psychological treatment ($n = 6$), altered ($n = 8$) or initiated medication for somatic or psychiatric issues ($n = 10$).

3.2. Posttraumatic stress

In the intention-to-treat analyses, posttraumatic stress decreased during the first 3 months of app access in both conditions (Tables 2 and 3). The effect was small during the first three months of access in both groups. Furthermore, we only detected a negligible change in the instant access condition and a small effect in the delayed access condition during the follow-up (Tables 2 and 3). Posttraumatic stress decreased between 11 (instant access condition, Table 2) to 13 points (delayed access condition, Table 3) from baseline to the final follow-up. Posttraumatic stress reductions continued and were maintained during follow-up in both conditions (Tables 2 and 3). The unimputed analyses (Appendix: Table A3 and A4) revealed similar results; however, we only detected a significant improvement during the follow-up phase in the delayed access condition. Individual trajectories of participants and improvement from baseline to the 9-month follow-up are presented in Appendix: Fig. A1.

3.3. Depressive symptoms

In the intention-to-treat analyses, depressive symptoms decreased during the initial period of app access in both conditions (Tables 2 and 3). The effect was similar in both groups: small during the initial 3 months of app access and the symptom change was negligible during follow-up (Tables 2 and 3). Depressive symptoms decreased between 3 (instant access condition, Table 2) to 4 points (delayed access condition, Table 3) from baseline to the final follow-up. We did not detect an improvement or deterioration of depressive symptoms during the follow-up phase (Tables 2 and 3). The unimputed analyses revealed similar results (Appendix: Table A3 and A4).

3.4. Somatic symptoms

In the intention-to-treat analyses, the changes in somatic symptoms

Table 1

Average posttraumatic stress, depressive, somatic symptoms and functional disability (non-imputed) during 9 months.

Measure	RCT condition	Baseline			Post (3 months)			Follow-up (6 months)			Follow-up (9 months)		
		<i>m</i>	(<i>sd</i>)	<i>n</i>	<i>m</i>	(<i>sd</i>)	<i>n</i>	<i>m</i>	(<i>sd</i>)	<i>n</i>	<i>m</i>	(<i>sd</i>)	<i>n</i>
Posttraumatic stress	Instant access	36.44	(16.49)	89	27.47	(17.61)	73	26.06	(17.63)	65	25.28	(19.51)	63
	Delayed access	38.17	(15.42)	90	36.95	(18.13)	77	29.09	(17.00)	70	24.88	(16.89)	56
Depressive symptoms	Instant access	10.65	(6.79)	89	8.60	(6.07)	73	7.65	(6.06)	65	7.98	(6.84)	62
	Delayed access	11.11	(6.59)	90	11.36	(7.40)	77	9.01	(7.05)	70	8.29	(5.98)	56
Somatic symptoms	Instant access	11.43	(5.83)	89	10.48	(5.61)	73	9.57	(5.63)	65	9.00	(5.54)	62
	Delayed access	12.77	(5.22)	90	12.44	(5.19)	77	10.65	(5.57)	69	9.96	(5.68)	56
Functional disability	Instant access	30.83	(19.84)	89	24.07	(20.06)	72	21.54	(19.74)	64	21.24	(22.15)	62
	Delayed access	30.42	(19.80)	90	30.11	(20.11)	77	24.15	(18.49)	69	23.51	(20.18)	56

Note. Symptoms were measured with the Posttraumatic Symptom Checklist for the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Patient Health Questionnaire-9, Patient Health Questionnaire-15 and the World Health Organization Disability Assessment Schedule, 12-item version.

RCT = Randomized Controlled Trial.

Table 2

Parameter estimates, standard errors (*SE*), confidence intervals (*CI*) and effect sizes for the intention-to-treat multiple regression analyses of symptoms, functional disability and time among participants with instant access to PTSD Coach.

Outcome and effect	<i>B</i>	(<i>SE</i>)	95 % <i>CI</i>	<i>p</i>	Cohen's <i>d</i>	Cohen's <i>d</i> 95 % <i>CI</i>
Posttraumatic stress						
Intercept	36.44	(1.85)	32.79, 40.09	<0.001		
Time						
During app access (0–3 months)	−7.62	(1.56)	−10.70, −4.54	<0.001	−0.44	−0.60, −0.28
Follow-up (3–9 months)	−1.87	(0.89)	−3.63, −0.11	0.038	−0.11	−0.19, −0.02
Depressive symptoms						
Intercept	10.65	(0.68)	9.32, 11.99	<0.001		
Time						
During app access (0–3 months)	−2.03	(0.65)	−3.30, −0.75	0.002	−0.317	−0.50, −0.14
Follow-up (3–9 months)	−0.49	(0.36)	−1.20, 0.23	0.184	−0.076	−0.17, 0.02
Somatic symptoms						
Intercept	11.43	(0.59)	10.27, 12.59	<0.001		
Time						
During app access (0–3 months)	−0.99	(0.52)	−2.02, 0.03	0.058	−0.177	−0.35, −0.01
Follow-up (3–9 months)	−0.77	(0.29)	−1.34, −0.20	0.008	−0.139	−0.23, −0.05
Functional disability						
Intercept	30.83	(2.12)	26.66, 35.00	<0.001		
Time						
During app access (0–3 months)	−5.70	(1.80)	−9.25, −2.15	0.002	−0.285	−0.45, −0.12
Follow-up (3–9 months)	−2.20	(1.00)	−4.18, −0.22	0.030	−0.110	−0.20, −0.03

Note. One unit in time represents 3 months. Thus, the total change in outcomes between 3 and 9 months is $B \times 2$. $N = 89$.

Table 3

Parameter estimates, standard errors (*SE*), confidence intervals (*CI*) and effect sizes for the intention-to-treat multiple regression analyses of symptoms, functional disability and time among participants with delayed access to PTSD Coach.

Outcome and effect	<i>B</i>	(<i>SE</i>)	95 % <i>CI</i>	<i>p</i>	Cohen's <i>d</i>	Cohen's <i>d</i> 95 % <i>CI</i>
Posttraumatic stress						
Intercept	38.17	(1.77)	34.68, 41.65	<0.001		
Time						
Before app access (0–3 months)	−1.01	(1.63)	−4.21, 2.19	0.536		
During app access (3–6 months)	−7.89	(1.73)	−11.29, −4.49	<0.001	−0.47	−0.65, −0.29
Follow-up (6–9 months)	−4.27	(1.84)	−7.89, −0.65	0.021	−0.26	−0.43, −0.08
Depressive symptoms						
Intercept	11.11	(0.71)	9.72, 12.50	<0.001		
Time						
Before app access (0–3 months)	0.25	(0.72)	−1.16, 1.67	0.725		
During app access (3–6 months)	−2.55	(0.75)	−4.04, −1.07	<0.001	−0.38	−0.58, −0.18
Follow-up (6–9 months)	−0.80	(0.77)	−2.33, 0.72	0.299	−0.12	−0.32, 0.08
Somatic symptoms						
Intercept	12.77	(0.56)	11.67, 13.86	<0.001		
Time						
Before app access (0–3 months)	−0.40	(0.53)	−1.43, 0.64	0.449		
During app access (3–6 months)	−1.89	(0.56)	−2.99, −0.78	<0.001	−0.36	−0.54, −0.17
Follow-up (6–9 months)	−0.79	(0.60)	−1.98, 0.39	0.187	−0.15	−0.33, 0.03
Functional disability						
Intercept	30.42	(2.05)	26.39, 34.44	<0.001		
Time						
Before app access (0–3 months)	0.06	(1.75)	−3.37, 3.49	0.973		
During app access (3–6 months)	−6.58	(1.87)	−10.25, −2.90	<0.001	−0.34	−0.54, −0.17
Follow-up (6–9 months)	−1.18	(2.04)	−5.20, 2.84	0.562	−0.06	−0.23, 0.11

Note. One unit in time represents 3 months. $N = 90$.

during the first 3 months with app access differed in the two conditions. In the instant access condition, somatic symptoms decreased during the follow-up phase, yet we only detected a trend for decreased somatic symptoms after three months access to PTSD Coach (Table 2). In contrast, we detected a decrease in somatic symptoms among delayed access participants following 3 months access to PTSD Coach, but no difference at the follow-up (Table 3). The changes were negligible in both groups, except for a small effect during the initial 3 months of app access in the delayed access group (Tables 2 and 3). Somatic symptoms decreased 3 points in both conditions (Tables 2 and 3) from baseline to the final follow-up. The unimputed analyses revealed similar results (Appendix: Table A3 and A4).

3.5. Functional disability

The between-group intention-to-treat analysis indicated that functional disability improved among instant access participants during 3 months access to PTSD Coach as compared to delayed access ($B = -5.39$, $SE = 2.49$, $CI = -10.28, -0.50$, $t(301.83) = -2.17$, $p = 0.031$; Cohen's $d = -0.27$). The unimputed analysis also indicated that functional disability improved during initial access to PTSD Coach ($B = -5.89$, $SE = 2.43$, $CI = -10.70, -1.08$, $t(147) = -2.42$, $p = 0.017$).

In the within-group intention-to-treat analysis, functional disability decreased in both conditions during the first 3 months of app access (Tables 2 and 3). The decrease in functional disability progressed and was maintained during the follow-up phase among instant access participants (Table 2). We did not detect changed functional disability among delayed access participants during follow-up (Table 3). The effect was small during the initial 3 months of app access and the change was negligible during follow-up in both groups (Tables 2 and 3). Functional disability decreased between 10 (instant access condition, Table 2) to 8 % (delayed access condition, Table 3) from baseline to the final follow-up. The unimputed analyses revealed similar results (Appendix: Table A3 and A4).

3.6. Helpfulness, satisfaction and negative effects

A few participants did not report helpfulness, satisfaction and negative effects (Appendix: Table A5 and A6). The delayed access participants ($n = 63$) deemed PTSD Coach as slightly helpful. The average total perceived helpfulness of PTSD Coach was 17.25 ($sd = 14.97$). The delayed access participants did, on average, find PTSD Coach slightly to moderately satisfactory ($m = 1.80$, $sd = 1.30$, $n = 59$).

Thirty-five participants (57.4 %, $n = 61$) reported no negative effects. The other participants, who experienced negative effects, reported between 1 and 8 negative effects (median = 2). The reported average intensity of experienced negative effects caused by using PTSD Coach was slight to moderate ($m = 1.71$, $sd = 0.77$) and the mean total intensity was low ($m = 2.08$, $sd = 3.65$). The most frequently reported negative effects caused by using PTSD Coach were for example experiencing more unpleasant feelings (6.6 %), triggering of unpleasant memories (11.5 %), not understanding the app (13.1 %), its content (13.1 %) or feeling like expectations of the app were not met (19.7 %; Appendix: Table A6). No participant reported suicidal thoughts or urges due to using PTSD Coach.

4. Discussion

The self-management intervention PTSD Coach aids and maintains slight, long-term alleviation of trauma-related symptoms and functional disability. The effects were comparable to (Hensler et al., 2022; Kuhn et al., 2017; Miner et al., 2016) or smaller than previously reported effects (Cernvall et al., 2018; Possemato et al., 2016). The app seemingly confers positive effects despite the low adherence in the group; approximately half of the delayed access participants reported actually using PTSD Coach, which was less compared to the instant access participants (Hensler et al., 2022), while the analyses revealed similar

effects.

Low rates of use are not unique to this study; most people use the app scarcely and use of PTSD Coach decreases over time (Hallenbeck et al., 2022). Unlike the delayed access participants, the instant access participants responded to daily surveys during 21 days regarding self-management app use as they gained access to PTSD Coach (Hensler et al., 2021), which we speculate may have prompted app use. Interestingly, we have previously noted a difference between the self-rated app use during the first weeks of access to PTSD Coach and the long-term recall of using the app (Hensler et al., 2022). As 13 people in the delayed access condition did not fully complete the 3-month assessment, they may not have received the app unless they reached out to the research group. Ideally, use of PTSD Coach would have been recorded during the entire trial. It is difficult to determine the true adherence rate without long-term, objective user data. The low reported use of PTSD Coach among delayed access participants could also indicate that a postponed access may undermine the motivation to use a self-management app. In a real world context, a self-management app can be instantly available for download.

In addition, alterations to the participants' other ongoing treatments could also confound to what extent symptom alleviation is attributable to PTSD Coach. Nevertheless, a majority reported no changes in their concurrent treatment, and the alterations were evenly distributed across conditions at the post assessment (Hensler et al., 2022). Confounding changes were evenly distributed among delayed access participants who used PTSD Coach or did not use PTSD Coach. The potential confounding changes in treatment among the delayed access participants during access to PTSD Coach were similar to the reported frequencies of the instant access participants (Hensler et al., 2022). Seeking new types of trauma-focused treatment was the exception, as it appeared that fewer delayed access participants ($n = 4$) endorsed this than instant access participants ($n = 17$; Hensler et al., 2022), although this was not statistically verified.

We detected no clear nocebo effect for delayed access participants; there were essentially no change in symptoms during the 3-month waiting period for the delayed access group and the benefit of app access was comparable to that of the instant access group after 3 months. Among delayed access participants, we only detected long-term improvement of posttraumatic stress. In contrast, posttraumatic stress, somatic symptoms and functional disability continued to improve in the instant access group during follow-up. A similar length of follow-up (6 months) as the instant access group would have enabled a direct comparison of the long-term effects. Overall, we believe that access to PTSD Coach is a plausible reason behind the observed, within-group changes in symptoms and functional disability in the delayed access group, similarly to the observed development in the instant access group in this study and the RCT (Hensler et al., 2022). The absence of change in outcomes before access, the observed changes during the first 3 months following access to PTSD Coach, as well as the even distribution of confounding factors, support this conclusion.

The delayed access participants considered PTSD Coach similarly or less helpful compared to the instant access group participants (Hensler et al., 2022) and previous studies (Cernvall et al., 2018; Kuhn et al., 2014; van der Meer et al., 2020). The overall satisfaction was lower (Hensler et al., 2022). Version differences and unmet expectations after a lengthy wait could explain the disparate results in the separate conditions. The intensity of negative reactions appeared similar to instant access participants, while the average total intensity was lower (Hensler et al., 2022). The relatively low perception of the app's quality and negative effects such as disappointment in the app may impact to what extent it is actually used (Olff, 2015). We note that the Swedish app since the data collection has been updated to version 3.1 (Hallenbeck et al., 2022) with changes that may affect usability and thus the satisfaction with the app across versions.

To conclude, limitations in this study were the irregularity and subjectivity of reported app use, low reported use of PTSD Coach, the

employment of an inactive waitlist and the uneven gender ratio in the sample. The strengths of this study include the large, clinically relevant sample, the extended follow-up, satisfying retention rates and the measurements of symptoms as well as functional disability and negative effects.

4.1. Clinical considerations and future research

We only detected within-group improvement in posttraumatic stress past the initial access to PTSD Coach in both conditions. Others have suggested that longer access to PTSD Coach (exceeding one month) may be beneficial for reducing posttraumatic stress (van der Meer et al., 2020). In general, small effect sizes were detected after 3 months of app access and only for posttraumatic stress during follow-up for the delayed access participants. Moreover, the principal impact of having access to the PTSD Coach probably occurs within a shorter timeframe when you consider the decline in utilization over time (Hallenbeck et al., 2022). Although we detected symptom change after months of use, user data suggest that using a PTSD Coach exercise can also decrease momentary distress (Hallenbeck et al., 2022). Therefore, distress alleviation could hypothetically be instantaneous. It is uncertain within what timeframe a stable improvement of mental health and functional disability is detectable and, more importantly, perceived by users of PTSD Coach. These temporal relationships are of interest for people who research, recommend and use technology-assisted therapy or self-management tools at large.

The effective components of PTSD Coach that stimulate improvement and long-term maintenance of symptom reduction are, to the best of our knowledge, an unresolved enigma. Reported frequency of using PTSD Coach has been unrelated to changes in outcomes in the current and other samples (Hensler et al., 2021; Kuhn et al., 2017; Miner et al., 2016). Our investigation of the participants' coping strategies that correspond to the app components indicates the importance of social support (Hensler et al., 2021). However, we did not explore the actual use of PTSD Coach modules. Other researchers argue that the inclusion of avatars (a digital embodiment of a person), interactive social support or automated support, in app interventions could improve efficacy of interventions (Goreis et al., 2020; Linardon et al., 2019). Passive and active data collection within mental health apps could permit detailed observation and investigation of effective mechanisms as they unfold in everyday life. Study designs such as factorial or A/B designs could clarify mechanisms of change in order to find specific targets relevant for intervention content and design of remote trauma-focused interventions (Andersson et al., 2019; Hallenbeck et al., 2022; Steubl et al., 2021). Others have suggested that mechanisms of change after access to PTSD Coach might be improved coping, social support, knowledge, symptom awareness, hope and reduced stigma that assist self-efficacy and seeking professional treatment (Kuhn et al., 2017, 2018).

Utilization of self-management apps may be less emotionally taxing compared to exposure-based face-to-face interventions, but they can still trigger unwanted symptoms. The most common symptom-related negative effect was resurfacing of unpleasant memories, which was reported by approximately every tenth participant in the delayed access group. This is noteworthy, since coping with being reminded of the trauma is the most common reason PTSD Coach users (23.23 %) search for coping exercises within the app (Hallenbeck et al., 2022). Increased suicidality is a common concern with self-management apps, which was not endorsed by any responding participant. It is an ethical and personal decision whether the potential suffering outweighs the benefits of using a self-management app.

Some argue that self-management apps may only be helpful for people with mild symptoms, in contrast to people with an established PTSD diagnosis (Goreis et al., 2020). The moderate symptom severity in our sample indicates that people with greater symptom burden may benefit as well. Granted, we did not investigate efficacy on an individual basis and greater posttraumatic stress was related to attrition. We

detected improved posttraumatic stress, somatic symptoms and functional disability during follow-up as well in the instant access group (but not for depressive symptoms). The individual trajectories (Appendix: Fig. A1) indicate that improvement is seen among people with high as well as low levels of posttraumatic stress at baseline. However, the decrease in symptoms was modest to minimal, and may be perceived as quite unfulfilling for a person who struggles with trauma. Nevertheless, the app has potential to confer benefits on a population level (Hallenbeck et al., 2022). As self-management apps have been suggested as interventions in stepped care (Ameringen et al., 2017; Andersson et al., 2019; Linardon et al., 2019), it is vital to know when the option might have exhausted its impact and a new clinical decision should be made. Clinical practice would benefit from determining for whom the app is effective (Hallenbeck et al., 2022) by exploration of individual characteristics that moderate successful symptom alleviation or negative effects when utilizing the app, to recommend or advise against using PTSD Coach on an individual basis.

5. Conclusions

After receiving the self-management app PTSD Coach, participants reported decreased symptoms of posttraumatic stress, depression, somatic illness and functional disability within 3 to 9 months. The improvement was stable over several months and posttraumatic stress continued to improve during follow-up. PTSD Coach has a small effect, but research has thus far not conclusively determined why and for whom. Exploration of mechanisms behind reduction of distress and individual factors that predict intervention success would advance the research of mobile interventions and the implementation of PTSD Coach in clinical practice.

CRedit authorship contribution statement

FKA acquired funding.

IH, JS, MC and FKA contributed to the conceptualization and methodology.

IH performed the investigation.

FKA and IH performed the formal analysis.

IH wrote the original draft.

FKA, JS and MC reviewed and edited the manuscript.

FKA, JS and MC supervised the project.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

We have no financial or personal interests to declare.

Data availability

A dataset supporting the main conclusions of this article is available per request at <https://doi.org/10.17605/OSF.IO/F6P3R> (Hensler and Arnberg, 2020). The dataset has no demographic variables in order to protect participant identities. We welcome reasonable requests for extended data from qualified researchers.

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Appendix A. Supplementary materials

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