RESEARCH ARTICLE

Effects of an online treatment for pediatric sleep problems on emotion dysregulation in young children

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Abstract: *Background*: Pediatric sleep problems are strongly linked to future emotional problems. However, research regarding the effect of internet-based cognitive behavior therapy for insomnia (iCBT-I) in early childhood on the outcome of emotion dysregulation is missing. *Participants*: 200 children (47% female) aged 7 to 63 months (M = 23.13) suffering from behavioral insomnia participated in the Mini-KiSS 6-week online treatment. *Methods*: A pre-post-follow-up design was implemented. Sleep disorders were stated according to ICSD-3 and DSM-5 criteria and emotional dysregulation was assessed with an emotion dysregulation profile for children. Difference scores were calculated, a repeated-measures ANOVA, and stepwise multiple linear regression was performed. *Results*: After iCBT-I Mini-KiSS for young children, emotion dysregulation significantly declined immediately after the intervention (*p = 0.000)* and in the follow-up measurement after three months (*p = 0.002*). Age was associated with the change in emotion dysregulation at follow-up measurement (*p = 0.017)*. Gender or the type of sleep disturbance did not have statistically significant impact on change in emotion dysregulation at any measurement (*p ≥ 0.05*). Clinically significant improvement of emotional dysregulation was achieved in 14.5% of the children from pre- to post-measurement, and 25.3% improved at follow-up. *Conclusions*: The findings show that treatment of pediatric insomnia reduce emotion dysregulation of infants and toddlers. Therefore, early sleep intervention might prevent mental disorder in young children. In future, an extended longitudinal design is needed to examine the preventing power of early-improved sleep on later psychopathological disorders. Beyond, future studies should examine underlying mechanisms in more detail.

Keywords: emotion dysregulation, pediatric sleep, behavioral insomnia in childhood, internet-based intervention, infants, toddlers

1 Introduction

1.1 Infant and toddlers sleep and emotion dysregulation

Empirical evidence supports a close association between problematic sleep and shortcomings in emotion regulation [1–3]. Among the harmful consequences of problematic sleep during childhood is the heightened risk of developing psychiatric disorders, including depression, anxiety, and pathological emotion and mood dysregulation [4–8]. A growing part of research proposes that harmful relationships between sleep problems and psychopathological risk may be rooted in impaired emotion regulation [1,7,9] Shortcomings in emotion regulation are associated with expressions of abnormal mood states regarding sadness and anger, hyperarousal and display of distinctly increased emotional reactivity towards negative emotional stimuli [10].

The association between sleep problems and emotion dysregulation, as concerning as it is, becomes even more serious considering that about 20% to 30% of infants and toddlers are affected by behavioral sleep problems during the first three years of life [11–13] Predominant problems of toddlers are night awakenings and difficulties in initiating sleep [14, 15]. These behavioral sleep problems cause a fragmented sleep and shorter night sleep durations [16].

While a sufficient amount of sleep is associated with a high degree of adaptability of the child and emotional regulatory ability, *e.g.*, during social interaction tasks [17,18], short sleep predicts more aggressive behavior or hostility in young children [19]. Additionally, after short sleep, higher stress reactivity and higher level of negative emotion expression were observed in slightly stressful situations, for example during a brief separation from the mother [20].

1.2   Age, sleep problems and gender influencing the children's emotional dysregulation

Achieving the competence of emotional regulation is an important developmental task [21], which requires to perceive and understand one's own emotional experiences [22]. From the perspective of developmental research, these attempts include utilization of physiological, attentional, emotional, and behavioral processes related to emotion regulation [23]. These abilities are expected to improve proportional to age and become more sophisticated and integrated throughout developmental processes [24, 25]. For example, attentional control processes emerge at the end of infancy and at the beginning of toddlerhood and are used to control an individual's emotion and behavior [25, 26].

Previous findings indicate that especially night awakenings in children are associated with more dysregulated behavior such as hyperactivity and dysfunctional involvement in peer group problems [27]. This was supported by Mindell's and colleagues [28] finding of night awakenings to be associated to decreased social competence, whereas no further emotional outcomes seemed to be affected [28]. Another study addressing the context of different behavioral sleep problems and emotional functioning also found night awakenings not to be associated to the emotional outcome measures, whereat difficulties to falling asleep in pre-school children significantly predicting symptoms of depression as well as anxiety [29]. Additional research found nocturnal awakenings as well as difficulties falling asleep in two years old toddlers to be significantly associated with social-emotional problems [30]. In accordance with the cross-sectional studies, long-term consequences of pediatric sleep problems were detectable, too. Presence of bedtime problems (*e.g.*, difficulty initiating sleep) in childhood was found to be associated to internalizing problems in adolescence and later depression [31]. In sum, results of present research demonstrate that specific, yet relatively common sleep problems have short- as well as long-term impact on children's emotion regulation.

Furthermore, there is an indication of female infants being more sensitive to the effects of short sleep by displaying more dysregulated behavior than male infants later on [32]. Beyond, especially female children with early sleep problems were more emotional problems and more symptoms of anxiety and depression in the middle childhood and had more emotional regulation problems than boys [33]. The role of gender is also supported by experimental studies as only female toddler's mood states of depression and anxiety deteriorated in consequence of sleep restriction [34].

1.3   Treatment of early sleep problems

Corresponding to longitudinal research, untreated behavioral sleep problems as insomnia symptoms often persist from infancy to later childhood [15, 35–37]. About a third of children affected by sleep problems in early childhood showed disturbed sleep 1 to 2.5 years later [38]. This high rate of persistence of sleep problems also has long-term consequences for emotion regulation [39].

Fortunately, CBT for behavioral sleep problems in young children is effective [40–43]. Points of criticism of traditional CBT-I programs are the limited availability and the lack of process individuality through inflexible time schedules [44, 45]. The internet is a widely used source for parents in examples of multiple child related matters and, in contrast to traditional face-to-face consultations, web-based interventions are highly available for the target group and have the benefit of being individualized through flexible time management [46].

Furthermore, online treatment of pediatric sleep problems was found to be marginally associated with *e.g.* improved infant's morning mood [44], and this might be a protecting factor against dysregulated emotional behavior throughout the day [47].

1.4   Study objectives

In sum, empirical evidence, identified in certain cross-sectional as well as longitudinal studies, indicate a mutual association between pediatric sleep problems and different emotion related constructs [17, 18, 20, 33]. Nonetheless, while the relation between sleep problems and affective symptoms is well-established, there is still a demand for more research to investigate the mutual directions by which sleep and emotion regulation are associated [28]. However, no previous study proved the effects of an online cognitive behavioral therapy for insomnia (iCBT-I) on emotion (dys)regulation of young children.

In order to fill this gap, the overall objective of the current study was to investigate the effect of an online cognitive behavioral treatment for pediatric sleep problems (iCBT-I) "Mini-KiSS" on emotion dysregulation in toddlers. Therefore, this study (1) aimed to test the improvement of

emotion dysregulation in young children suffering from behavioral insomnia at pre-measurement before the Mini-KiSS online intervention, immediately after (post-measurement), and at follow-up after three months. (2) In addition, based on previous research we will prove influencing factors of change in emotion dysregulation such as age, type of sleep disorder, and gender.

2 Methods

2.1 Design and procedure

This study realized a pre-post-follow-up design. Participants were recruited in cooperation with sleep laboratories and pediatric centers and an advertising article published in a popular parent magazine. After the pre-measurement phase (week 1 to 2), parents participated in the "Mini-KiSS" online training (MKO) (week 3 to 8). Immediately after training, parents filled in the post-test measurements (week 9 to 10). In addition, three months after the post-test, participants completed the follow-up measurements (week 22).

2.2 Ethics statement

Prior to participation in the study participating parents were informed about the goal, procedure, content, and any other relevant aspects of the study. All parents were informed that they had the right to refuse to participate in the study or to withdraw consent to participate at any time without any penalties. Participation was absolutely voluntary. Psychologists were not involved in any otherwise dependent relationship with the participating parents. The e-mail communication during the treatment and information about the study and its conditions were standardized. Only participants who were able to give informed consent were included. Parents declared their willingness to participate and gave informed consent prior to the diagnostic entry. The study was conducted according to standard ethical guidelines as defined by the Declaration of Helsinki and approved by the ethics committee of the department of medicine of the University of Tuebingen.

2.3 Participants and dropout rates

An a priori power analysis with G×Power v. Faul et al. [48] for repeated measures ANOVA with three times of measurement and an α of 0.05, power of 0.95, and effect size n^2_p of 0.1 revealed that N = 141 participants would be required for statistical significance.

Table 1 Family characteristics

	N = 200	%
Gender		
female	94	47.0
male	103	51.5
missing	3	1.5
Who completed the questionnaire		
father alone	-	-
mother alone	21	10.5
both parents	179	89.5
Living situation		
with biological parents	194	97.0
single mother	3	1.5
single mother with new partner	1	0.5
other circumstances	2	1.0
Siblings		
single child	127	63.5
child with brother or sister	63	31.5
missing	10	5.0

Families were included if (1) they reported insomnia symptoms (sleep onset problems or night wakings on most nights) sleep disturbance of their child not caused by an organic disease, (2) the child was within the target age group (0.5 to 4 years of age), (3) the parents understand the German language, and (4) the child had no other mental or developmental diagnosis. The study was approved by the Ethics Committee (Commission of Medical Ethics of Tübingen). Informed written consent was obtained from all parents before study entry.

223 families were interested to participate in the study. All participants were Caucasian. Parents of 200 children completed the pre-measurements (89.69%). The children were aged 7 to

63 months (M = 23.13, SD = 13.40). Gender was nearly equally distributed across the sample (94 girls (47%), 103 boys (51.5%)).

Table 1 presents the family characteristics of the sample. 179 questionnaires were completed from both parents. Most children lived in their birth families (N = 194), and were singletons (N = 127) at pre-test assessment.

Of the 200 participants who completed the pre-test, 145 completed the post-test (dropout N = 56; 27.86%). Of the 145 participants who completed the post-test, 82 completed also the three-month follow-up (dropout N = 63; 43.45%). Analyses show that families who completed the post-, as well as the follow-up measurement and families who dropped out throughout the study did not differ in age and gender of the child, living situation of the parents, number of siblings and the child's sleep problems.

3 Instruments

3.1 Anamnestic sleep questionnaire and classification of insomnia

The Mini-Kiss Online Questionnaire was implemented to assess the demographic information (*e.g.* age, gender, occupation) and symptoms of insomnia according to the DSM-5 and ICSD-3 criteria for insomnia (sleep onset latency, duration and frequency of night awakenings, refusals at bedtime) [49, 50]. Thresholds regarding sleep latencies and duration of night awakenings were added in accordance with Gaylor and colleagues with respect to children's age [51]. The whole questionnaire contains 11 sections with 44 items [52]. Answers were given on a 4-point Likert-scale with "0" representing problematic sleep behavior is never displayed and "3" representing problematic sleep behavior is mostly or usually present for a minimum of 5 times per week.

The parent-identified sleep problems are divided into the categories of difficulties initiating sleep and difficulties maintaining sleep.

Difficulties in initiating sleep were given when:

(1) The child's sleep onset latency exceeds 30 minutes for children from 12-23 months and 20 minutes for children at the age of 24 months, on a minimum of three evenings per week.

(2) Difficulties initiating sleep without caregiver intervention on a minimum of three evenings per week.

(3) The child shows refusing behaviors (*e.g.* getting out of bed, standing up in bed) while going or putting to bed on a minimum of three evenings per week.

Difficulties maintaining sleep were present when parents reported:

(1) Difficulties maintaining or returning to sleep without caregiver intervention on a minimum of three evenings per week.

For children from 12-23 months pertains a threshold of waking up twice for minimum of 10 minutes after sleep onset. For older children (24 months or older) the threshold is defined as waking up at least one time per night, with a minimum of being awake for 20 minutes during the whole night.

3.2 Emotion Dysregulation Profile for Children (EDP-C)

The emotion dysregulation profile for children (EDP-C) was derived from the Child Behavior Checklist 1,5-5 (CBCL) [53]. The original profile was based on the subscales (a) anxious/depressed, (b) attention/hyperactivity problems and (c) aggressive behavior problems of the CBCL 4-18 in measuring mood dysregulation in adolescents [8]. To adopt the profile to children of younger age, the original dysregulation items of the CBCL 4-18 were transformed to the CBCL-1,5-5 version. Additionally, the emotionally reactive subscale is included in the EDP-C for the reason of a more detailed representation of emotion dysregulation. In total 43 items were added to a sum score ranging from 0 to 86. Higher values indicate a higher pathological indication of emotion dysregulation. Items can be scored on a 3-point Likert scale ranging from "0" - representing "not true", "1"- "somewhat true", and "2"- "very true". The EDP-C achieved an acceptable reliability α of 0.88, 0.86 and 0.81 at the pre-, post- and follow up measurement. This study applied a cut-off of T scores $\geq$ 60 on the EDP-C in reference to Spencer and colleagues [54]. Previous studies assessing a CBCL based dysregulation profile [55] defined a cut-off for T scores $\geq$ 70 (2SD) for severe forms of emotional dysregulation. As our sample is non-clinical and none of the children in this sample demonstrated that degree of pathological dysregulation, we determined a cut-off for T scores $\geq$ 60 (1SD) represented by EDP-C scores $\geq$ 24 for a sub-syndrome emotional dysregulation in accordance to Spencer and colleagues [54]. See the supplemental material for a detailed presentation of the included items.

3.3 Intervention: Mini-KiSS online

One of the internet-based CBT-I treatments (iCBT-I) for infants and toddlers concerning sleep problems is the Mini-KiSS Online (MKO) study [52]. MKO was adapted on the basis of the evaluated face-to-face Mini-KiSS sleep treatment, a multimodal group therapy program for parents with 0.5 to 4 years old children suffering from behavioral sleep disturbances [43]. Mini-KiSS combines cognitive-behavioral (CBT-I) and imaginative strategies. In MKO families receive six weekly treatment sessions based on a bibliotherapeutic self-learning approach via E-mail (topics *e.g.* psychoeducation, sleep hygiene, bed time ritual, graduate extinction, token system, information about feeding, baby massage). Material of each session was divided into parts focused on sleep education and parent behavior. The content is available as a written workbook to sum up individual behavior plans and progress. Additive material is given to the participating families: (1) the stuffed leopard "Kalimba" to adopt the imaginative/hypnotherapeutic strategies (imagination and breathing) for children; (2) bedtime stories for children; (3) imaginative exercises were uploaded in audio format for parents. Communication before and during treatment was standardized via E-mails as far as possible.An overview of the different contents is presented within the supplemental material. First evaluations showed that the children's sleep behavior improved significantly after the MKO treatment [52]. These improvements were comparable to the face-to-face group intervention [43].

3.4 Data analysis

All analyses are conducted using IBM SPSS Statistics version 25. Demographic characteristics are displayed using means (M) and standard deviations (SD). Normal distribution is tested with Shapiro-Wilk test.

3.4.1 Change in emotion dysregulation

Addressing the first aim, a repeated-measures ANOVA is used. If data are normally distributed, the change over time in emotion dysregulation are analyzed with a parametric repeated-measures ANOVA, with three measurements (pre-test, post-test, follow-up). Otherwise, non-parametric Friedman's ANOVA is used. Pairwise comparisons have been adjusted for the number of measurements ($p_{adj} = p \times k$, with p being the original p-value and k being the number of measurements (3)).

Next to statistical significance and effect sizes, this study will investigate the clinical significance of change in emotion dysregulation. For testing the clinical change over the three measurements, difference scores were calculated with the formula [56]:

$$x_{\text{change}} = x_{\text{pre}} - x_{\text{post}}$$

$$x_{\text{change.FU}} = x_{\text{pre}} - x_{\text{follow-up}}$$

A positive difference score represented an improvement in the emotion dysregulation, a negative one a deterioration. Then, reliable difference scores have been calculated according to Jacobson and Truax [57]:

1) Calculate the instruments' pre-test standard error, $S_E = S_{\text{pre}} \sqrt{(1 - r_{\text{xx}})}$

s_{pre} as the standard deviation of the instruments' pre-test score

r_{xx} as the instruments' internal consistency

2) Calculate the instruments' standard deviation of the errors, $S_{\text{Diff}} = \sqrt{\left(2 \left(S_E\right)^2\right)}$

3) Calculate the RCI = $S_{Diff} \times 1.96$

Frequency distributions of the clinical changes have been presented using percentages.

Whereas the calculation and utilization of a clinically significant difference score is reliable and expressive for an individual sample [57], we proved how many participating children achieved or exceed the EDP-C cut-off score of 24.

3.4.2 The impact of age, gender, and category of sleep problem

The impact of age, gender, and sleep problem categories on the change in emotion dysregulation (x_{change} and $x_{change.FU}$) was examined with a stepwise multiple linear regression. Potential deviation from normal distribution was corrected with bootstrapping (1000 iterations). Multicollinearity was investigated with tolerance and variance in factor. The impact of age, gender, and sleep on clinical changes in emotion dysregulation was examined with a logistic regression analysis that mirrored the settings from the stepwise multiple linear regression. The level of statistical significance was set at 0.05.

3.4.3   Missing data and effect sizes

Only missing data at follow-up measurement were substituted, as replacing post-measurement data might distort the training effects [58]. Missing data at follow-up measurement was analyzed for missing completely at random with Little's MCAR test [59]. If MCAR was present in the data, then missing follow-up measurements were replaced using hot deck imputation [60]. For replacing the missing values, "deck variables" were chosen considering the criteria of (a) little to no missing data, (b) discrete values, and (c) their relatedness to the variable being substituted [61]: gender, age, and emotion dysregulation at pre-measurement. Effect sizes were reported in Cohen's d for parametric data (d = 0.20 small; d = 0.50 moderate; d = 0.80 large), r for nonparametric data (r = 0.10 small; r = 0.30 moderate; r = 0.50 large), and adjusted R^2 change for the regression analyses.

4   Results

4.1   Emotion dysregulation: Continuous outcomes

Data were not normally distributed. Therefore, Friedman's nonparametric repeated-measures ANOVA was used. Figure 1 displays emotion dysregulation development across the three measurements up to 3 months after treatment. Overall, a significant effect of time was stated (Z = 18.50, $p = 0.000$). Emotion dysregulation significantly decreased from pre-measurement to post-measurement (z = 3.80, $p = 0.000$, r = 0.24) and to follow-up measurement (z = 3.45, $p = 0.002$, r = 0.22) with small to moderate effect sizes. These results were stable and slightly decreased further at 3 months' follow-up.

Note: ** p ≤ 0.01, *** p ≤ 0.001
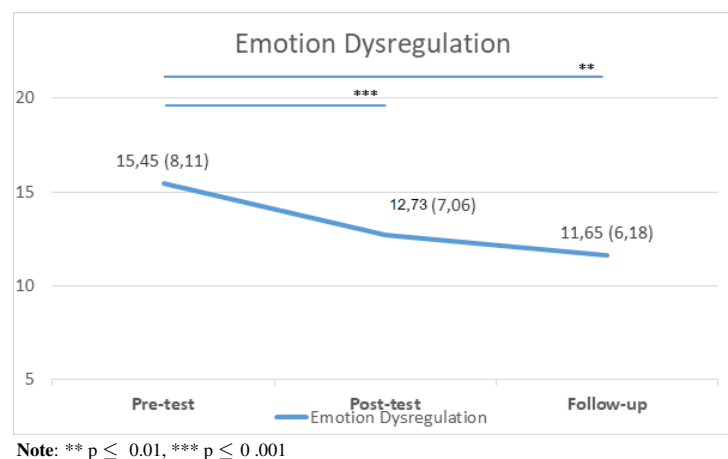
Figure 1   Change of the emotion dysregulation score from pre- to follow up measurement

According to the introduced cut-off score of 24 for the EDP-C we proved the number of children exceeding this score. Out of the 82 children we found eleven children with a subclinical form of emotion dysregulation at pre-measurement. The development of emotion dysregulation in this group and in the group of children without symptoms of emotion dysregulation is presented in Table 2. As shown, both groups improved across the three points of measurement. The group of subclinical emotion dysregulation improved in their dysregulation beneath the cut-off score at post-measurement with further improvement at follow-up. To acknowledge we did not perform any further analysis of group differences of children with vs. without symptoms of emotion dysregulation for the risk of producing unrepresentative results and because results will have no statistical power due to small and different sample sizes in the EDP-C groups of children [48, 62].

4.2   Emotion dysregulation: Clinical significance

According to the calculation formula of Jacobson and Truax [57], clinically significant change in emotion dysregulation was declared at a difference score of 9 points or larger, with +9 points indicating clinical deterioration and -9 points indicating clinical improvement. Figure 2 shows the number of participants with clinically improvements at post- and follow-up measurement. 14.5% (n = 12) of the children showed less emotional dysregulation symptoms from pre- to

Table 2 Fdescriptive development of emotion dysregulation in the groups of subclinical and no emotion dysregulation at pre-measurement

EDP-C group Measurement	Sublinical emotion dysregulation (N = 11)			No emotion dysregulation (N = 71)		
	Range	M	SD	Range	M	SD
Pre-test	25-37	30.45	4.34	2-23	13.38	5.44
Post-test	8-34	17.00	7.89	2-21	11.42	6.94
Follow-up	1-25	14.00	6.78	0-19	10.8	6.07

Note: N: Number; SD: standard deviation; EDP-C: emotion dysregulation profile for children. Values are group means and standard deviation. Percentages refer to the cellular N. Classification in "subclinical emotion dysregulation" as EDP-C at pre-measurement > 24 and "no emotion dysregulation" if EDP-C at pre-measurement $\leq$ 24. According to the different sample sizes information is purely descriptive.

post-measurement, and 25.3% (n = 21) percent improved at follow-up. 4.1% (n = 3) and 7.6% (n = 6) deteriorated respectively. However, most of the children did not display clinically significant changes in emotion dysregulation after post-measurement (81.4%, n = 67) and at 3 months-follow-up measurement (67.1%, n = 55).
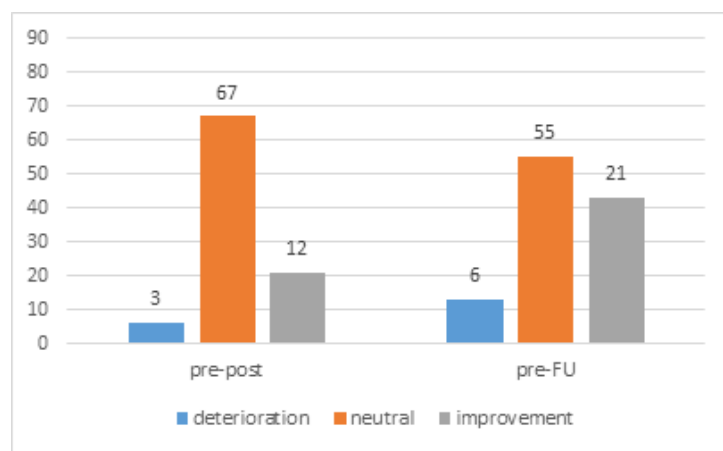
Figure 2 Number of participants who improved, deteriorated or without change in emotion dysregulation according to the clinical change score from pre to post and from pre to follow up measurement.

4.3   The impact of age, gender, and insomnia on emotion dysregulation

As data were not normally distributed, bootstrapping was performed. Due to missing data in the predictors (especially age), the sample size was N = 82 participants for all regression analyses.

4.3.1   Predictors of Change in Emotion Dysregulation

Results of the stepwise multiple linear regression analysis with change in emotion dysregulation from pre- to post-measurement as outcome variable showed that neither the first model with the two predictors age and gender was significant (F (2,84) = 0.695, $p = 0.502$, R^2 = 0.000), nor the second model with the additional, third predictor sleep problems (F(4,80) = 0.883, $p = 0.478$, R^2 = 0.000), see Table 3. Stepwise multiple linear regression analysis showed that the child's age and gender together predicted whether child had altered their emotion dysregulation when measured in the pre- to follow-up measurement. In detail, the first model including the two predictors age and gender achieved nearly significance (F (2, 90) = 3.054, $p = 0.052$, R^2 = 0.043). However, gender alone was no significant predictor of emotion dysregulation change from pre- to follow up measurement (B = 1.651, SE = 1.771, $p = 0.343$). In contrast, age significantly predicted change in emotion dysregulation (B = 0.172, SE = 0.072, $p = 0.017$) showing that older children have a greater improvement concerning emotion dysregulation than younger children three months after the training. During stepwise linear regression, the second model with the additional predictor sleep problems was not significant (F (2, 88) = 2.214, $p =$

0.115, $R^2 = 0.068$). All confounder variables age, gender and sleep problems were removed, based on their p-values $\geq$ 0.05. All in all, age, gender, and type of sleep problem do not have impact on the reduction in emotion dysregulation at post-measurement, but age affects the reduced emotion dysregulation at follow-up measurement.

4.3.2 Predictors of Clinically Significant Changes in Emotion Dysregulation

The stepwise logistic regression analysis from pre- to post-measurement showed that neither the first model with the two predictors age and gender was significant ($X^2 = 2.073$, $p = 0.355$, $R^2_{Nagelkerke} = 0.046$), nor the second model with the additional predictor type of sleep problems ($X^2 = 4.166$, $p = 0.384$, $R^2_{Nagelkerke} = 0.092$).

Table 3 Results of the logistic regression from pre- to follow-up measurement

	B	SE	p
Gender	0.458	0.659	0.408
Age	0.056	0.028	0.007**
sleep onset problems	0.868	0.656	0.135
night awakenings	0.171	0.717	0.788

Note: * p $\leq$ 0.05, ** p $\leq$ 0.01, *** p $\leq$ 0.001

Stepwise logistic regression analysis from pre- to follow-up measurement showed that the first model with the two predictors age and gender was significant ($X^2 = 7.79$, $p = 0.020$, $R^2_{Nagelkerke} = 0.122$). Although gender itself was no significant predictor of change concerning emotion dysregulation at follow-up (B = 0.458, SE = 0.627, $p = 0.399$), age significantly predicted this change (B = 0.050, SE = 0.023, $p = 0.012$). The second model with the additional predictor sleep problem was also significant ($X^2 = 10.275$, $p = 0.036$, $R^2_{Nagelkerke} = 0.159$). Table 3 presents results of the second model for each predictor. The predictor age was significant. In detail, in older children a greater emotion dysregulation reduction was reported than in younger children. As the p-values of gender, as well as sleep onset problems and night waking's were > 0.05, they were removed from the model.

In sum, the present study showed that iCBT-I for young children aged 0.5 to 4 years significantly reduces emotion dysregulation directly after intervention and at three months' follow-up measurement. Older children had a higher improvement in emotion dysregulation at follow-up measurement. Mediating factors like gender, or type of sleep problem as sleep onset problems, or night awakenings did not have statistically significant impact on this change in emotion dysregulation.

5   Discussion

The findings of this study support the presumption that, after completing iCBT-I, children significantly reduce emotional dysregulation. Our findings are in line with experimental and correlative studies showing adequate sleep to be associated with better emotion regulation competence [63–66]. In addition, our results are consistent with a model proposed by Kahn et al. [67], in which a sufficient amount of sleep facilitated the functional interaction between the individual and the environment. This functional interaction might be a supporting factor in generating adaptive emotional responses and less dysregulated behavior [20, 41].

The improvements shown in our study were demonstrated in various ways – first, the statistically significant reduction in emotion dysregulation immediately after training, second, with a long-term effect after three months at follow-up and third, with a modest effect size for the introduced intervention in improving emotion dysregulation. Our findings are supported by Mindell and colleagues, albeit they reported a small effect size for an online iCBT-I intervention to improve parents' perception of their children's mood [44]. This was also supported by a former study with Mini-KiSS as face-to-face version reported statistically significant improvements in emotional constructs, *e.g.* emotional reactivity and aggressive behavior after the intervention [69].

Furthermore, another striking finding is the clinically relevant improvement concerning emotion dysregulation in almost a quarter of the children at the three months-follow-up. In detail, 21 children improved their emotional dysregulation from pre- to post-test and 43 children at the follow up. Whereas we can describe the samples change in emotional dysregulation by the use of the sample-based difference score [57], we are not able to assert that "pathologically dysregulated children" improved to "normal regulated children". Therefore, future research

should generate normative data and prove the mentioned cut-off score of the presented EDP-C profile for clinically relevant outcomes [70].

As mentioned, there were 11 out of 82 children with an indication of sub-clinical emotion dysregulation at pre-measurement. For the mentioned reasons, we reported it purely descriptive, and found an immoderate improvement of emotion dysregulation in this subclinical group. Whereas, this finding could be rated as first answer of the demanded assessment of the impact of sleep intervention on a child's emotional outcomes [28,68], results are not generalizable and the reliability of this purely tendentially finding is not proven yet and validation remains open for future research. But the current pilot findings are supported by Deng [70] as well as Wang and colleagues [71] postulating that the chance to rehabilitate from emotional problems increased in consequence of improvement of sleep problems. To recapitulate, treatment for pediatric insomnia may be beneficial for improving the child's functionality, learning, aggression and social behavior [72]. If future studies can confirm this finding in a controlled study design, this would be groundbreaking for the sleep and emotion research society. Namely to that way, that conjectures will be replaced by an evidence of treatment of sleep problems not only increase sleep quality, but also may prevent psychopathological consequences of problem sleep in children high at risk for dysregulated behavior. In sum, an association between development of emotional problems due to early sleep problems can be assumed, whereas the reverse association is still to debate and evidence is rare [33,73,74].

In addition, it should be noted that older children had a stronger reduction in emotion dysregulation after iCBT-I. As most children begin to manage their own emotions by improving their language skills in preschool age [75,76], the findings of our study might be explained by age per se. However, as the trainings lasted only six weeks, age might not explain all improvements concerning emotion regulation. Future studies should include further assessments to distinguish between effects of age, and developmental status, which could also be a predictor of improvement in dysregulation after treatment of pediatric sleep problems [26].

The absent effect of gender on improving emotional dysregulation after MKO intervention can be explained by a comprehensive synthesis of the results of previous studies. In several studies, gender differences in sleep problems cannot be shown in samples from toddlers [12,14,17]. But regarding the long-term consequences of sleep problems, longitudinal research found females' in contrast to males' emotional functioning to be sensitive to pediatric sleep problems [33]. As these gender-specific differences in emotion regulation are likely to emerge in the preschool and school years [78], the change in emotional dysregulation in infants and toddlers immediately, and three months after a iCBT-I treatment might be unaffected from gender. To explore the role of gender on the possible long-term benefits of an adequate sleep pattern on emotion (dys)regulation, future intervention research should apply more sustainable longitudinal study designs.

In contrast to previous research postulating especially fragmentation of night time sleep to be associated to dysregulated behavior [27], the improvements regarding emotion dysregulation are significant for all sleep disturbances – for difficulties falling asleep and also for night awakenings. Our findings are consistent with research results in pathologically dysregulated school-age children, assuming no association between specific sleep problems and pathological dysregulation [8]. As all results are based on questionnaires and sleep logs future research should implement also objective sleep indicators, such as actigraphy or polysomnography to examine the exact influence of various sleep problems on emotion dysregulation.

6   Consideration and outlook

The present study is the first to evaluate the efficacy of an online-delivered iCBT-I to improve emotion dysregulation in a sample of normally developed young children suffering from behavioral sleep disturbances according to ICSD-3 or DSM-5 criteria. As mentioned, research findings are often overestimated due to analyzing and interpreting data on their statistical significance exclusively [69]. Within this study, the calculation of clinically relevant changes in emotion dysregulation was included to overcome this analytical limitation. Furthermore, operationalization of "emotion (dys)regulation" is still a challenging issue [79]. Therefore, an undisputed strength of the current study is the introduced emotion dysregulation profile for children, enabling future, as well as already finished intervention research studies, utilizing the CBCL 1.5-5 in their assessment battery, to explore the program's effect on emotion dysregulation.

As an initial study in this area, the present study also has some limitations. First, due to our drop-out rates we did not achieve the recommended sample-size (141 demanded vs. 82 included), thus the statistical power of our analysis is restricted [48]. Second, although the CBCL is one of the most accepted instruments to assess the child's behavioral problems, and the CBCL

dysregulation profile for school-aged children and adolescents is well established predicting psychopathology in early adulthood [80], the introduced emotion dysregulation profile for infants and toddlers is mostly unexplored. Although the internal consistencies were good in this sample, caution should be given to interpretation of the findings until further psychometric data is available from other samples. Furthermore, the need for prove the suggested cut-off scores to assess clinically relevant emotion dysregulation remains open for future research. Third, the present design employed subjective, parental-report measures. Individual measures may provide an incomplete picture of the positive effect of improved sleep on emotion regulation [1]. For an integral picture, it would be useful to acquire for example behavioral, physiological as well as neuroimaging of emotion regulation in addition to subjective measures. Fourth, the generalizability of the present results is restricted to the homogenous character of the present sample of physical and mental healthy toddlers. Fifth, although a 3-months follow-up period is considerable, a longer follow-up period would be useful. Thus, one of the key questions for ongoing research is to explore whether the perceptible positive effect of improved pediatric sleep on emotional dysregulation is stable for longer time periods or whether it diminishes.

7 Conclusion

Overall, these preliminary findings suggest that online treatment of pediatric sleep problems could be helpful to reduce emotion dysregulation. Whereas a beneficial impact is implied, much remains to be understood about the improved sleep-improved emotion dysregulation relationship. Increased experimental research exploring this positive association is necessary to give record on how improved sleep might contribute to improvement of specific emotional deficits.

Additionally, the preventing power of early improved sleep through CBT-I treatment for long-term negative consequences of unhealthy infant sleep including depression, anxiety or pathological emotion regulation needs to be clarified through future research.

Conflict of interest

Professor Schlarb holds the professorship for clinical psychology and psychotherapy for children and adolescents at the Bielefeld University. No conflicts of interest exist.

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