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Delivery room skin-to-skin contact for preterm infants—A randomized clinical trial

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Abstract

Aim: To investigate the effects of 60 minutes delivery room skin-to-skin contact (DR-SSC) compared with 5 minutes visual contact (VC) on mother-child interaction (MCI), salivary cortisol, maternal depression, stress and bonding at 6 months corrected age.

Methods: A single-centre randomized controlled trial conducted in a German level III NICU. Eighty-eight preterm infants (25-32 weeks of gestational age) were randomized after initial stabilization to either 60 minutes DR-SSC or 5 minutes VC. Forty-five infants were allocated to DR-SSC, 43 to VC.

Results: Delivery room skin-to-skin contact dyads showed a higher quantity of maternal motoric (18 vs 15, P = .030), infant's vocal (7 vs 5, P = .044) and motoric (20 vs 15, P = .032) responses. Moreover, the combined score of maternal and infant responsive behaviour was higher (86 vs 71, P = .041) in DR-SSC dyads. DR-SSC mothers had lower risk of both, early postpartum depression (15% vs 45%, P = .003) and impaired bonding (Score 3 vs 5, P = .031).

Conclusion: In addition to regular intermittent kangaroo mother care, DR-SSC promotes MCI and decreases risk of maternal depression and bonding problems. Thus, DR-SSC may have positive effects on preterm development.

KEYWORDS
mother-infant bonding, premature infant, skin-to-skin contact

1 | INTRODUCTION

Baby-friendly hospital initiatives worldwide recommend immediate and continuous skin-to-skin contact (SSC) after birth.[1] For preterm infants, SSC in the form of intermittent kangaroo mother care (iKMC) is well established in most modern neonatal departments but separation of mothers and their preterm infants immediately after birth is still standard. Intermittent KMC is frequently started only after days particularly in very preterm infants.[2]

A growing body of evidence from animal and human studies [3-6] indicates that the first hours after birth are important for the forming of a tight bond between mother and infant. This concept of an 'early sensitive period' was introduced more than 40 years ago and was triggered by the observation that extended contact of mother

Abbreviations: ADHD, Attention deficit hyperactivity disorder; BPD, Bronchopulmonary dysplasia; CA, Corrected age; CPAP, Continuous positive airway pressure; CRIB, Clinical Risk Index for Babies; DR-SSC, Delivery room skin-to-skin contact; FIP, Focal intestinal perforation; GA, Gestational age; HPA, Hypothalamic-pituitary-adrenal; iKMC, intermittent Kangaroo mother care; IVH, Intraventricular haemorrhage; KMC, Kangaroo mother care; LISA, Less invasive surfactant application; MCI, Mother-child interaction; MV, Mechanical ventilation; NEC, Necrotizing enterocolitis; NICU, Neonatal intensive care unit; PBQ, Parental Bonding Questionnaire; PEEP, Positive end-expiratory pressure; PSI, Parental Stress Index; PVL, Periventricular leucomalazia; SSC, Skin-to-skin contact; VC, Visual contact.

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and infant during after birth increased maternal affectionate attention towards her child.[7] In their RCTs, Bystrova[3] and later Dumas[4] observed that separation of mothers and their full-term infants resulted in more roughness in maternal behaviour at day four and worse attunement of the dyads 1 year later, although all results were within normal ranges.

The 'early sensitive period' is characterized by a special neuroendocrine situation. Probably mediated by oxytocin, maternal sensitivity increases and a (subconscious) learning process begins shaping mother-child interaction within the first year of life via gradual mutual adaption. A high level of maternal sensitivity and contingent responsiveness to the infant's needs improves the quality of mother-child interaction and eventually increases the chance of a secure attachment pattern.[8]

Preterm infants are at an increased risk of neurodevelopmental delay as well as behavioural disorders.[9] It was suggested, that sensitive mothering leads to a 'cooperative pattern' of MCI. Preterm infants classified in a 'cooperative pattern' had significantly less behavioural problems compared with preterm infants classified in a 'controlling pattern'.[10].

Additionally, in the NICU environment, the combination of maternal separation and exposure to stress and pain has been postulated to alter HPA axis reactivity.[11] In very preterm infants, immaturity and higher exposure to pain and stress were associated with a dampened response in salivary cortisol at 4 months of corrected age.[12]

Furthermore, preterm mothers are at an increased risk of postpartum depression. Separation from the infant and preoccupation with the infant's health may exert a negative effect on the maternal emotional state and parental self-image.[13]

Taking all this into account, we hypothesised that delivery room SSC (DR-SSC) may positively influence mother-child interaction (MCI) compared with dyads who started SSC in the form of iKMC later and had only had visual contact (VC) in the delivery room. We assessed MCI at 6 months of age corrected for prematurity (corrected age [CA]). Secondly, we expected that DR-SSC attenuates the dampening of salivary cortisol response observed in preterm infants. Thirdly, we assumed that DR-SSC may have positive effects on maternal depression, stress, breastfeeding and bonding quality. As confounders potentially influencing MCI, we assessed socioeconomic factors and perceived social support.

Key notes

- Delivery room skin-to-skin contact (DR-SSC) as an add on to regular intermittent kangaroo mother care promotes mother-child interaction in preterm infants.
- DR-SSC of preterm infants can be performed without increasing short-term complications of prematurity.
- DR-SSC decreases the risk of maternal depression and impaired bonding.

2 | PATIENTS AND METHODS

2.1 | Study design and recruitment

The delivery room skin-to-skin study was a single-centre randomized controlled parallel group study conducted at a level III German NICU. The ethics committee of the University of Cologne approved the study. All preterm infants born between 25 + 0 and 32 + 0 weeks of gestation between October 2013 and July 2015 were screened for eligibility. Additional inclusion criteria were as follows: firstborn child, single pregnancy and parental written informed consent. Infants were excluded if they had a severe underlying disease (severe malformations and syndromic disorder), needed resuscitation after birth (5-minute Apgar score <5) or had cardiopulmonary failure (FiO_2 > 0.4 or severe apnoea). Additionally, mothers with mental disorders (eg depression) or lack of German language skills were excluded.

The study is registered: NCT01959737 (https://clinicaltrials.gov).

2.2 | Randomization

Initial stabilization was carried out according to the local protocol for delivery room stabilization of preterm infants.[14] Immediately after birth, the infants were placed on the delivery room unit with a prewarmed mattress and a radiant heater. Infants were wrapped in a polyethylene cover and received sustained continuous positive airway pressure (CPAP) via a face mask with a variable flow CPAP device (Benveniste valve, Dameca) to recruit lung volume. FiO_2 was set to 0.21 and a gas flow of 15 L/min was used resulting in a positive end-expiratory pressure (PEEP) of about 8 cm H_2O. Depending on the infant's breathing efforts, heart rate and FiO_2, both gas flow and supplemental oxygen were adapted. Target ranges for heart rate were as follows: >120/min after 3 minutes and >85% for oxygen saturation after 10 minutes. Infants were intubated if heart rate remained <120/min or if the infant did not start to breathe after gas flow was increased to a maximum of 20 L/min. Less invasive surfactant application (LISA) was performed in infants with signs of respiratory distress (Silverman Score >5 and/or FiO2 >0.3 to keep saturation >85%) after 20-30 minutes.[15]. Before the LISA procedure, a gastric tube was inserted to prevent abdominal gas accumulation. Additionally, peripheral venous access was established and intravenous fluids were started. Antibiotics and caffeine citrate were given at the discretion of the attending neonatologist.

Randomization was performed approximately 45 minutes after birth if infants were deemed eligible (no severe apnoea, FiO2 <0.4). At this time, LISA (if indicated) was finished and the infant had sufficiently recovered from the procedure to evaluate stability for DR-SSC. Additionally, after 45 minutes, most mothers were transferred from the operating room to the room planned and equipped for DR-SSC.

Infants were randomly assigned to 60 minutes of DR-SSC with their mothers supervised by the attending neonatologist or to

5 minutes of VC. Randomization was done with sequentially numbered, sealed opaque envelopes by an independent statistician. A 1:1 ratio with variable block sizes was used.

2.3 | Study intervention

Infants in the intervention group received DR-SSC according to the following protocol: DR-SSC started approximately 45 minutes after birth and was performed for 60 minutes continuously supervised by the attending neonatologist. Infants were placed naked on their mother's chest in comfort position (eg left or right lateral) and covered with a transparent polyethylene wrap (NeoWrap™, Fisher & Paykel Healthcare) and a blanket. Room temperature was set to 24°C by automatically controlled heating. Infants' heart rate, respiratory rate, FiO_2 and oxygen saturation were recorded continuously. Temperature was measured by a skin sensor as long as the infant was placed on the delivery room unit but not during DR-SSC/VC for technical reasons. Fathers were encouraged to be present during the intervention but DR-SSC was restricted to mothers. Potential disturbances (medical staff entering and leaving the room, frequent talking of the supervising neonatologist to staff or parents) were to be kept at a minimum to give the parents the opportunity to completely concentrate on their infant. VC infants visited their mothers for 5 minutes after initial stabilization. Infants were carried by the staff to their mothers wrapped in NeoWrap™ and a towel. Mothers were allowed to touch but not kiss their infant's face during VC. Additionally, mothers were not allowed to unwrap their infant, so touching of hands, body and feet was not possible. After 5 minutes, infants were transported to the NICU, the attending neonatologist supervised the infant continuously. Visual contact mothers were allowed to touch their infant´s face and hands.

After DR-SSC or VC, infants were transferred to incubator care at the NICU. Mothers (and fathers) of both groups were encouraged to daily visits and daily iKMC for at least 1 hour by the medical staff at the NICU, rooming in was not possible until the infant was transferred to intermediate care.

2.4 | Primary and secondary outcomes

Primary outcome was the quality of mother-child interaction at infant´s corrected age (CA) of 6 months. At 6 months of CA, a video (4 minutes) was recorded and analyzed. Mothers were asked to change the diapers and play with their children, just as they usually do at home. All video recordings took place in our video laboratory after it was ascertained that the infants were awake, alert and not hungry. Two cameras were used to record mother and infant simultaneously in a split screen technique. Maternal and infant behaviour was assessed using the Mannheim Rating System, a well validated standardised observation instrument.[16] Videos were analysed by two trained raters blind to randomization. To facilitate coding, a computer program was used (INTERACT®, Mangold 1998). Interrater reliability was ≥0.70 for all subscales.

Maternal responsiveness comprised all behaviours executed as a response to the infant behaviours using different communication channels (vocal, facial or motor responsiveness). Maternal stimulation included all eliciting behaviours that tend to attract the infant's attention to begin an interactional sequence with him/her. Lack of responsiveness was coded when the mother did not react, although a response or an action was expected or needed. In addition, infant vocal, facial and motor responsiveness was assessed accordingly. Maternal positive mood was coded whenever the mother clearly smiled at the infant or when she was laughing, singing, speaking, whistling or verbally imitating the infant in response to his/her behavior. Negative mood was recorded whenever the mother showed a facial expression of anger, disappointment, sadness or contempt. A slight display of one of these facial expressions was sufficient for coding in this category. Infant positive mood was coded when the baby clearly smiled at the mother or vocalised in a positive manner, including laughing. Negative mood was defined as a distinctive vocal sign of discomfort such as crying, whining, wailing, or screaming or in case of a clear distinctive negative facial expression of the infant.

All behaviours were analysed in time intervals of 5 seconds and were coded if they were observed in the interval (event coding). The variables were built from the sum of each observed behavior.

Prespecified secondary outcome measures were reactivity of HPA axis at 36-40 weeks' postmenstrual age assessed by analysis of salivary cortisol before and 20 minutes after a heel lance. Non-pharmacologic analgesic methods including 1 mL glucose 20% and non-nutritive sucking on finger or pacifier were applied to all infants before the heel lance. Infants could be fed until 1 hour before the heel lance.

Saliva was collected by a small cotton roll (Sugi®), which was placed in the infant's mouth. The reliability of this method for newborn infants has been demonstrated.[17]

Saliva was expressed into a vial (Microtube®, Sarstedt) by centrifugation for 10 minutes at 894 *g*, stored at −20°C, and subsequently transported to ImmunoBiological Laboratories International (IBL) GmbH for analysis. Cortisol was assayed in duplicate using the IBL Cortisol Luminescense Immunoassay (RE 62011). Reportable ranges for cortisol were 0.005-4 µg/dL. Intra- and interassay coefficients of variation were 5.7 and 9.5%, respectively. We examined the relative cortisol increase (increase divided by baseline cortisol multiplied by 100) instead of absolute cortisol increase since baseline cortisol was a significant factor of influence on the increase.

Self-reporting methods were used to identify the secondary outcomes depression, quality of bonding and parental stress and the potential confounders of MCI perceived social support and socioeconomic status. Questionnaires were handed out to mothers at the infant's 3rd day of life, at the infant's discharge from hospital and at infant's 6 months of CA.

Depressive symptoms were assessed with the German long form of the Center for Epidemiological Studies Depression Scale (CES-D).[18] Cut-off for being at risk of clinical depression is 23 points. Perceived social support was assessed with the short version of the F-SozU scale[19] (F-SozU K-22). For the assessment of parenting stress and quality of bonding, German versions of the Parenting

Stress Index[20] (PSI, Cut-off 60 [indicates] and the Parental Bonding Questionnaire [PBQ, Cut-off 12]) were used.[21]

Additionally, we assessed the following neonatal data and maternal data: Apgar score, arterial cord blood pH, prenatal steroids, clinical risk index for babies (CRIB II) score,[22] timing to full enteral feeds, breastfeeding at discharge, complications of prematurity (bronchopulmonary dysplasia (BPD[23]), surgery for focal intestinal perforation (FIP) or necrotizing enterocolitis (NEC), intraventricular haemorrhage (IVH[24]) and periventricular leucomalazia (PVL)), time on CPAP or mechanical ventilation, length of NICU and hospital stay, onset and daily duration of iKMC.

2.5 | Statistics

Statistical analysis was performed using IBM SPSS Statistics 24 for Windows (SPSS Inc.). Variables are described as median (IQR), mean ± standard deviation or absolute and relative frequency. Differences between groups were compared by t test for normally distributed data, Wilcoxon-Mann-Whitney test for other metric data or Fisher's exact test for categories. A two-sided *P*-value < .05 was defined as significant. All analyses were regarded as explorative. Odds Ratios for continuous variables were calculated by binary logistic regression and describe the difference in odds for an increase of 1 unit of the continuous variable.

TABLE 1 Baseline data, data on neonatal course and short-term complications

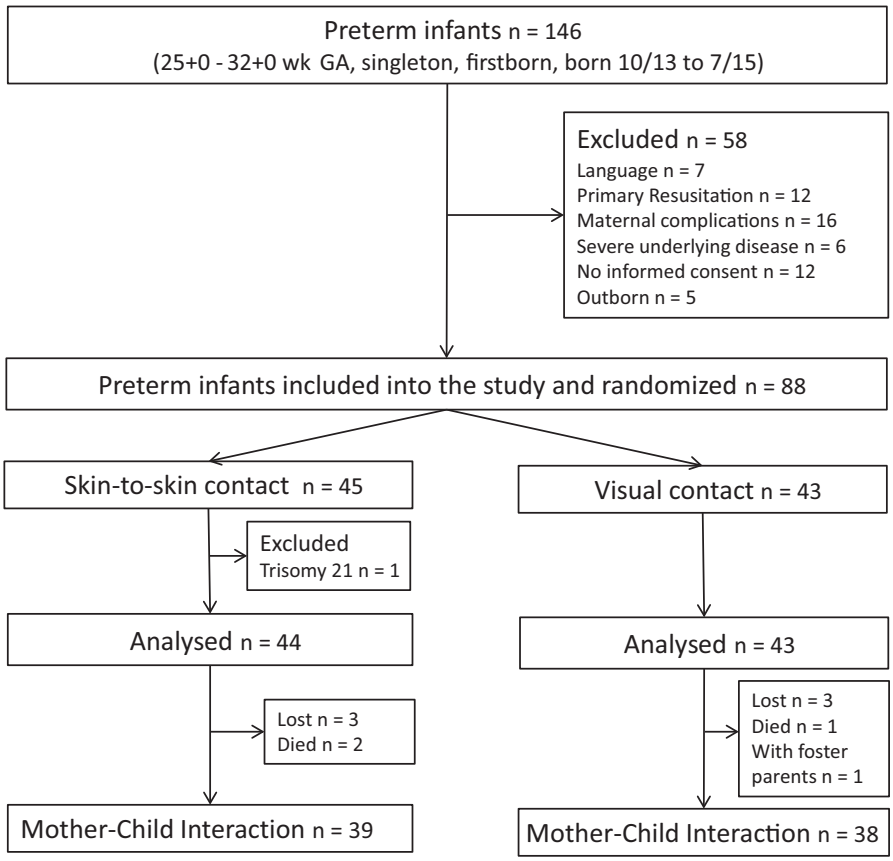
	DR-SSC (n = 44)	VC (n = 43)	*P*-value	OR (95% CI)
Baseline data				
Gestational age (wk, mean(sd))	29 (2)	29 (2)	.662	1.0 (0.8-1.3)
Birthweight (gram, mean (sd))	1250 (510)	1170 (380)	.470	0.7 (0.3-1.7)
Male (n (%))	21 (48%)	27 (63%)	.198	0.5 (0.2-1.3)
Caesarean section (n (%))	34 (77%)	33 (77%)	.998	1 (0.4-2.8)
Prenatal steroids (n (%))	35/41[a] (85%)	39/41[a] (95%)	.264	0.3 (0.6-1.6)
Apgar 5 min (median, IQR)	8 (7-8)	8 (7-8)	.233	1.2 (0.8-1.9)
Cord pH (mean, (sd))	7.28 (0.1)	7.28 (0.1)	.752	1 (0-260)
Analgetics for LISA (n (%))	10 (23%)	4 (9%)	.143	2.9 (0.8-10)
LISA (n (%))	37 (84%)	33 (77%)	.429	1.6 (0.5-4.7)
FiO_2 before VC/SSC) (mean ± sd)	0.24 (0.05)	0.25 (0.06)	.354	1.0 (1.0-1.1)
Upon NICU arrival				
FiO_2 (mean (sd))	0.23 (0.04)	0.24 (0.05)	.897	1.1 (1.0-1.2)
CPAP (mbar, mean (sd)	7.7 (1.7)	8.1 (1.8)	.272	1.2 (1.0-1.5)
Heart rate (bpm, mean (sd))	154 (15)	152 (14)	.569	1.0 (1.0)
Mean blood pressure (mmHG, mean (sd))	36 (8)	37 (8)	.272	1.0 (1.0-1.1)
Respiratory rate (mean (sd))	60 (14)	57 (16)	.383	1.0 (1.0)
Skin temperature (°C, mean (sd))	**36.6 (0.9)**	**36.1 (0.8)**	**.001**	**0.5 (0.3-0.9)**
Data on neonatal course				
CRIB II score (median, IQR)	2 (1-4)	1 (1-4)	.975	1.0 (0.8-1.1)
MV days (mean (sd))	1 (1.8)	1 (2.9)	.253	1.1 (0.9-1.4)
CPAP days (mean (sd))	13 (13)	12 (13)	.667	1.0 (1.0)
NICU days (mean (sd))	17 (14)	16 (15)	.747	1.0 (1.0)
Hospital days (mean (sd))	58 (31)	60 (30)	.825	1.0 (1.0)
Time to full enteral feeds (days, mean (sd))	13 (4)	14 (5)	.096	1.1 (1.0-1.2)
Short-term complications of prematurity				
IVH I and II (n (%))	9 (20%)	8 (19%)	.792	1.3 (0.5-3.7)
IVH III and IV (n (%))	1 (2%)	0		
PVL (n (%))	0	1 (2%)	.494	2 (1.7-2.5)
NEC/FIP (n (%))	2 (5%)	5 (12%)	.266	0.4 (0.1-2)
BPD (n (%))	2/43[a] (5%)	2/42[a] (5%)	1	1 (0.1-7.2)

Abbreviations: BPD, bronchopulmonary dysplasia; CPAP, continuous positive airway pressure; CRIB, clinical risk index for babies; FIP, focal intestinal perforation; IVH, intraventricular haemorrhage; LISA, less invasive surfactant application; MV, mechanical ventilation; NEC, necrotizing enterocolitis; NICU, neonatal intensive care unit; PVL, periventricular leucomalazia; SSC, skin-to-skin contact; VC, visual contact.

[a]Total stated due to missing data.

Bold values indicate statistically significant results.

FIGURE 1 Flow chart of the study



The required sample size was computed using Addplan software, version 5 (AddPlan GmbH). Sample size was calculated based on data of intervention programs to promote maternal sensitivity.[25] We assumed that DR-SSC may have comparable effects on maternal sensitivity, for example we expected an increase of maternal sensitivity (estimated by the number of maternal/infant responses) in DR-SSC mothers of 30%. With an allocation ratio of 1:1, these assumptions lead to a calculated sample size of n = 2 × 44 = 88 in order to be able to reject the null hypothesis of an equal number of maternal/infant responses with a type-I error probability of 5% and a power of 80%. Estimated drop-out rate was 7%.

TABLE 2 Results of MCI subscales

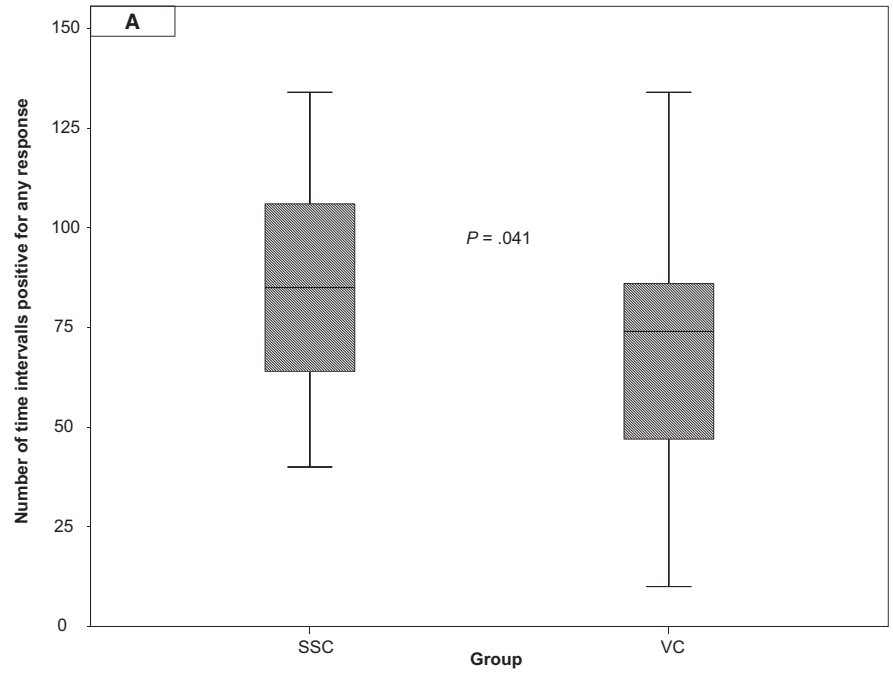
MCI Subscale	DR-SSC (n = 39)	VC (n = 38)	*P*-value
Maternal positive mood[a]	20 (±12)	17 (±10)	.281
Maternal negative mood[a]	0.4 (±1)	0.5 (±2)	.962
Infant positive mood[a]	6 (±7)	6 (±8)	.943
Infant negative mood[a]	2 (±3)	1 (±3)	.225
Insensitive maternal behavior[a]	4 (±4)	5 (±6)	.702
Maternal vocal stimulation[a]	20 (±8)	18 (±8)	.298
Maternal mimic stimulation[a]	10 (±7)	9 (±6)	.386
Maternal motoric stimulation[a]	14 (±7)	12 (±8)	.298
Maternal vocal response[a]	21 (±7)	18 (±9)	.113
Maternal mimic response[a]	13 (±5)	12 (±8)	.355
Maternal motoric response[a]	**18 (±6)**	**15 (±6)**	**.030**
Infant vocal response[a]	**7 (±6)**	**5 (±5)**	**.044**
Infant mimic response[a]	7 (±7)	7 (±7)	.694
Infant motoric response[a]	**20 (±9)**	**15 (±7)**	**.032**

[a]Mean number of time intervals coding for the respective subscale (±standard deviation).
Bold values indicate statistically significant results.

3 | RESULTS

Basic patient characteristics, information on the neonatal course and short-term complications of prematurity are presented in Table 1. The flow chart of the study is presented in Figure 1. Within the study period, 146 infants were eligible for inclusion of these, 88 were included in the study and randomized. One infant in the DR-SSC group was excluded from further analysis because he was diagnosed with Trisomy 21 (a predefined exclusion criterion) on the second day of life. Additionally, two intervention group infants and one control group infant died before the study was completed. Cause of death was severe sepsis on 7th day of life in one DR-SSC infant and severe pulmonary embolism on the 9th day of life in one VC infant. Another DR-SSC infant died from volvulus at the age of 4 months.

The primary outcome of our study was analysis of MCI (Table 2, Figure 2A,B). The overall rate of intervals positive for maternal and infant responsive behaviour (including all types of responses: vocal, motoric and mimic) was significantly higher in DR-SSC mother-infant



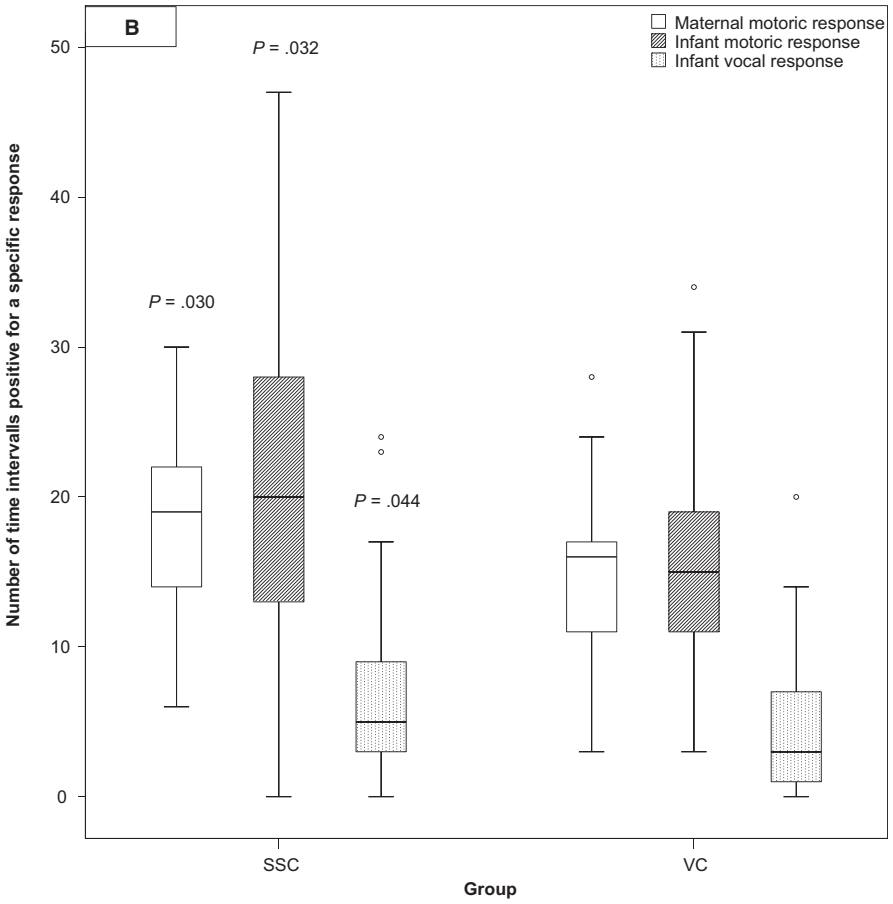


FIGURE 2 A and B, Mother-child interaction. A, Number of time intervals coding for either maternal or infant responsive behaviour (y-axis showing number of time intervals positive for any response); B, Number of time intervals coding for maternal motoric, infant motoric or infant vocal behaviour (y-axis showing number of time intervals positive for a specific response)

dyads compared with VC dyads (86 [±26] vs 71 [±32], *P* = .041, OR 0.982, CI [0.7-1]). In detail, mothers of DR-SSC infants showed a higher rate of motoric responsive behaviour and DR-SSC infants showed responsive behaviour (motoric and vocal) more frequently after maternal stimulation.

For assessment of HPA axis reactivity, sufficient saliva samples yielding data on both, baseline and peak cortisol levels in order to calculate relative cortisol increase was available for 34/44 (77%) DR-SSC and 37/43 (86%) VC infants. There was no difference in baseline cortisol levels between VC infants (0.8 [±0.9] µg/dL) and DR-SSC

TABLE 3 Secondary outcomes and potential confounders of MCI

	DR-SSC (n = 44)	VC (n = 43)	*P*-value	OR (95% CI)
Secondary outcomes				
Depressive symptoms 3rd day of life (%)[b]	**6/39[a] (15%)**	**19/42[a] (45%)**	**.003**	**0.2 (0.1-0.6)**
ADS-L score at 3rd day of life (mean(sd))	**16 (8)**	**20 (10)**	**.044**	**1.1 (1.0-1.1)**
Depressive symptoms at discharge (%)	13/43[a] (30%)	12/39 (31%)	1	1 (0.4-2.5)
ADS-L at discharge (mean(sd))	17 (10)	18 (11)	.796	1.0 (0.9-1.0)
Depressive symptoms at 6 mo' CA (%)	2/33[a] (6%)	4/33[a] (12%)	.672	0.5 (0.1-2.8)
ADS-L score at 6 mo CAI (mean(sd))	10 (8)	9 (8)	.480	1.0 (0.9-1.0)
PBQ Score impaired bonding	**3 (0-15)**	**5 (0-30)**	**.031**	**1.1 (1.0-1.3)**
PSI total score (mean (sd))	49 (30-70)	51 (30-70)	.559	1.0 (1.0-1.1)
PSI maternal score (mean (sd))	49 (30-70)	53 (30-70)	.572	1.0 (1.0-1.1)
PSI infant score (mean (sd))	49 (36-70)	51 (30-70)	.916	1.0 (0.9-1.0)
Exclusive breast milk at discharge (n (%))	37/43[a] (86%)	29/42[a] (69%)	.072	2.8 (0.9-8.2)
Potential confounders of MCI				
Perceived social support at discharge (mean (sd))	4.6 (3.6-5)	4.6 (3-5)	.572	0.7 (0.2-1.7)
Perceived social support at 6 mo CA (mean (sd))	4.7 (1-5)	4.7 (3-5)	.484	1.0 (0.4-2.1)
Monthly household income (mean (sd))	2500-3000€	3000-4000€	.614	1.0 (0.8-1.1)
Graduated from high school (%)	31/43[a] (72%)	28/39[a] (72%)	1	1.0 (0.4-2.7)

Abbreviations: CA, corrected age; PBQ, Parental Bonding Questionnaire; PSI, Parental Stress Index.
[a]Total stated due to missing data.
[b]Cut-off 23 points.
Bold values indicate statistically significant results.

(0.5 [±0.5] µg/dL, *P* = .197). We observed a diminished relative increase of salivary cortisol after the heel lance in VC infants compared with DR-SSC infants (52% vs 76%, *P* = .071) but the differences did not reach statistical significance.

Additionally, we observed a significant higher rate of maternal depressive symptoms on the 3rd day of life and a poorer quality of bonding (assessed at 6 months of CA) in the control group. Of note, no differences were observed regarding cofactors such as perceived social support, monthly income or rate of graduation from high school. No difference was found between groups regarding parental stress (Table 3). Infants after DR-SSC had a significant higher skin temperature upon arrival at the NICU compared with VC infants. Regarding all other parameters, no significant differences between groups were detected. Rates for complications of prematurity were similar in both groups (Table 3). Onset and duration of iKMC did not differ significantly between groups. Mean onset of iKMC was the 3rd day of life for both groups (*P* = .212). This delay was mainly due to maternal discomfort in sitting down in a reclining chair shortly after the caesarean section. Mean daily, iKMC duration at NICU was 1.6 (±0.7) hours per day for DR-SSC infants compared with 1.7 (±1.2) hours per day for VC infants (*P* = .990). No severe adverse events were observed during DR-SSC. In five infants, one short, self-limiting apnoea was observed. For VC infants, heart rate, oxygen saturation and FiO2 were additionally recorded every 60 seconds and no adverse events were observed.

4 | DISCUSSION

Our RCT demonstrates that DR-SSC in preterm infants additionally to regular iKMC improves MCI at 6 months of CA without increasing complications of prematurity. The scales we used in our study have been previously applied in many studies to measure intervention effects or the influence of certain risk factors on maternal sensitive and responsive behavior.[26,27] Unfortunately, there are no normative values for these scales because it is difficult to define a 'universal' value above which the behaviour of both partners (mother and child) is inadequate; as each interaction is unique and mothers and infants are expected to react depending on the behaviour of the interaction partner.

There is a significant body of scientific evidence showing the positive effect of sensitive and responsive maternal behaviour on child development.[27] Especially in high-risk patients (ie infants born preterm, maternal postpartum psychiatric disorder), the protective effect of maternal positive interactional behaviour is relevant: higher levels of early maternal responsiveness, sensitivity and positive mood are significantly associated with higher levels of cognitive and social-emotional development of the infant.[28]

To optimise MCI, family-centered and developmental care strategies have been introduced in many neonatal departments, encouraging parents to frequent iKMC[29]

In contrast to these strategies, our study is to our knowledge one of the first to focus on the effect of a very early intervention in the delivery room. In contrast to our study focusing on MCI,

Kristoffersen et al are currently assessing the impact of DR-SSC on neurodevelopment in preterm infants.[30] As mentioned before, the first hour after birth represents a sensitive period of mother-child interaction[7] in which the basis of maternal sensitive behaviour is laid. In the present study, 60 minutes of DR-SSC affect MCI in a way that both, DR-SSC mothers and infants, showed significantly increased responsiveness compared with VC dyads. Sensitive responsiveness is a valid indicator of high quality mother-child interaction. We interpret the increase in maternal responsiveness as clinically relevant because comparable changes (increase in maternal sensitivity by >30%) were found in video-feedback interventions.[25]

Additionally, early depressive symptoms were identified only in 15% of DR-SSC compared witj 45% of VC mothers. The prevalence of postpartum depression following a premature delivery is high and has been mainly attributed to physical separation of mother and infants.[13] Separation causes anxiety for the infant's well-being and is a major stressor for mothers.[31] Additionally, mothers frequently experience feeling of guilt for not carrying to term. DR-SSC enables mothers to spend time with their infant after birth. During DR-SSC, the mothers realise that the infant is doing well and that she can provide a safe environment for her baby. These feelings may help to decrease maternal anxiety. Maternal depression is negatively associated with MCI[32] and poses a risk of neurodevelopmental delay and behavioural problems in preterm and full-term infants.[33] Thus, an intervention that reduces the risk of postpartum depression may help to improve infant outcome.

There were no adverse events associated with the study intervention. Comparable to reports of iKMC sessions, infants were not at risk of hypothermia.[34] Of note, although VC infants were covered in a transparent wrap and wrapped in a prewarmed towel before visiting their mothers, many arrived hypothermic at the NICU. DR-SSC was never interrupted for medical reasons. Of note, all infants showing signs of significant respiratory distress received surfactant before the intervention to avoid progression to severe respiratory distress.

Of further interest, more intervention group infants (86% vs 69%) exclusively received their mother's own breastmilk (either exclusively breastfeed or partly breastfed combined with bottle) at discharge. This observation is in line with data from full-term infants,[35] where the rate of exclusively breastfed infants was significantly higher after early SSC. We cannot exclude that breastfeeding may also have positively influenced MCI irrespective of DR-SSC.

Although we observed differences in outcome parameters between groups, our results barely reached statistical significance. This may be due to higher drop-out rates for MCI assessment than initially expected in an per se small sample size. Additionally, the measured values of MCI assessment and salivary cortisol scattered widely. Furthermore, our MCI videos were short compared with the original study. Clearer differences between groups may have only become apparent over longer observation time.

Our study has several limitations: Although DR-SSC improved quality of MCI, we did not evaluate neurocognitive outome or psychological aspects. Both investigations are planned when infants are 6 years old. Our study was limited to primapara because attachment quality is significantly influenced by the factor 'first child' as reported in predeceding study of our group.[5] Moreover, we did not assess MCI in full-term controls. Although MCI interaction was assessed by a blinded rater, blinding was not possible due to the nature of the intervention and may affect the results of the self-reporting questionnaires. Of note, mothers may have prepared themselves for the videotaping and tried to perform their best—but this would equally affect intervention and control group dyads.

5 | CONCLUSION

DR-SSC in preterm infants >25 (to 32 + 0) weeks of GA improves quality of MCI at 6 months of CA and reduces the risk of early postpartum maternal depression and impaired bonding without increasing short-term complications of prematurity.. Consequently, DR-SSC may have an impact on maternal sensitivity and maternal mental well-being. These factors are associated with improved development in premature infants.

CONFLICT OF INTEREST

None.

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REFERENCES

1. Brimdyr K, Cadwell K, Stevens J, Takahashi Y. An implementation algorithm to improve skin-to-skin practice in the first hour after birth. *Matern Child Nutr*. 2018;14(2):e12571.
2. Morelius E, Angelhoff C, Eriksson J, Olhager E. Time of initiation of skin-to-skin contact in extremely preterm infants in Sweden. *Acta Paediatr*. 2012;101(1):14-18.
3. Bystrova K, Ivanova V, Edhborg M, et al. Early contact versus separation: effects on mother-infant interaction one year later. *Birth*. 2009;36(2):97-109.
4. Dumas L, Lepage M, Bystrova K, Matthiesen AS, Welles-Nystrom B, Widstrom AM. Influence of skin-to-skin contact and rooming-in on early mother-infant interaction: a randomized controlled trial. *Clin Nurs Res*. 2013;22(3):310-336.
5. Mehler K, Wendrich D, Kissgen R, et al. Mothers seeing their VLBW infants within 3 h after birth are more likely to establish a secure attachment behavior: evidence of a sensitive period with preterm infants? *J Perinatol*. 2011;31(6):404-410.
6. Winberg J. Mother and newborn baby: mutual regulation of physiology and behavior–a selective review. *Dev Psychobiol*. 2005;47(3):217-229.
7. Klaus MH, Jerauld R, Kreger NC, McAlpine W, Steffa M, Kennel JH. Maternal attachment. Importance of the first post-partum days. *N Engl J Med*. 1972;286(9):460-463.
8. De Wolff MS, van Ijzendoorn MH. Sensitivity and attachment: a meta-analysis on parental antecedents of infant attachment. *Child Dev*. 1997;68(4):571-591.

9. Delobel-Ayoub M, Arnaud C, White-Koning M, et al. Behavioral problems and cognitive performance at 5 years of age after very preterm birth: the EPIPAGE Study. *Pediatrics*. 2009;123(6):1485-1492.
10. Forcada-Guex M, Pierrehumbert B, Borghini A, Moessinger A, Muller-Nix C. Early dyadic patterns of mother-infant interactions and outcomes of prematurity at 18 months. *Pediatrics*. 2006;118(1):e107-e114.
11. Anand KJ, Scalzo FM. Can adverse neonatal experiences alter brain development and subsequent behavior? *Biol Neonate*. 2000;77(2):69-82.
12. Grunau RE, Tu MT, Whitfield MF, et al. Cortisol, behavior, and heart rate reactivity to immunization pain at 4 months corrected age in infants born very preterm. *Clin J Pain*. 2010;26(8):698-704.
13. Flacking R, Lehtonen L, Thomson G, et al. Closeness and separation in neonatal intensive care. *Acta Paediatr*. 2012;101(10):1032-1037.
14. Kribs A, Roll C, Gopel W, et al. Nonintubated surfactant application vs conventional therapy in extremely preterm infants: a randomized clinical trial. *JAMA Pediatr*. 2015;169(8):723-730.
15. Mehler K, Grimme J, Abele J, Huenseler C, Roth B, Kribs A. Outcome of extremely low gestational age newborns after introduction of a revised protocol to assist preterm infants in their transition to extrauterine life. *Acta Paediatr*. 2012;101(12):1232-1239.
16. Esser G, Scheven A, Petrova A, Laucht M, Schmidt MH. The Mannheim rating scale for the assessment of mother-child interaction in infancy. *Z Kinder Jugendpsychiatr*. 1989;17(4):185-193.
17. Morelius E, He HG, Shorey S. Salivary cortisol reactivity in preterm infants in neonatal intensive care: an integrative Review. *Int J Environ Res Public Health*. 2016;13:3.
18. Radloff LS. The use of the Center for Epidemiologic Studies Depression Scale in adolescents and young adults. *J Youth Adolesc*. 1991;20(2):149-166.
19. Fydrich T, Tydecks S, Brähler E. Fragebogen zur sozialen Unterstützung (F-SozU): Normierung der Kurzform (K-14). *Z Med Psychol*. 2009;18:43-48.
20. Hofecker Fallahpour M, Benkert TN, Riecher-Rossler A, Stieglitz RD. Parenthood and parenting stress: psychometric testing of the Parenting Stress Index (PSI) in a German sample. *Psychother Psychosom Med Psychol*. 2009;59(6):224-233.
21. Reck C, Klier CM, Pabst K, et al. The German version of the postpartum bonding instrument: psychometric properties and association with postpartum depression. *Arch Women's Ment Health*. 2006;9(5):265-271.
22. Parry G, Tucker J, Tarnow-Mordi W, UK Neonatal Staffing Study Collaborative Group. CRIB II: an update of the clinical risk index for babies score. *Lancet*. 2003;361(9371):1789-1791.
23. Walsh MC, Szefler S, Davis J, et al. Summary proceedings from the bronchopulmonary dysplasia group. *Pediatrics*. 2006;117(3 Pt 2):S52-S56.
24. Papile LA, Burstein J, Burstein R, Koffler H. Incidence and evolution of subependymal and intraventricular hemorrhage: a study of infants with birth weights less than 1500 gm. *J Pediatr*. 1978;92(4):529-534.
25. Kalinauskiene L, Cekuoliene D, Van Ijzendoorn MH, Bakermans-Kranenburg MJ, Juffer F, Kusakovskaja I. Supporting insensitive mothers: the Vilnius randomized control trial of video-feedback intervention to promote maternal sensitivity and infant attachment security. *Child Care Health Dev*. 2009;35(5):613-623.
26. Buchmann AF, Kopf D, Westphal S, et al. Impact of early parental child-rearing behavior on young adults' cardiometabolic risk profile: a prospective study. *Psychosom Med*. 2010;72(2):156-162.
27. Holz NE, Boecker-Schlier R, Jennen-Steinmetz C, et al. Early maternal care may counteract familial liability for psychopathology in the reward circuitry. *Social cognitive and affective neuroscience*. 2018;13(11):1191-1201.
28. White-Traut RC, Rankin KM, Yoder J, et al. Relationship between mother-infant mutual dyadic responsiveness and premature infant development as measured by the Bayley III at 6 weeks corrected age. *Early Hum Dev*. 2018;121:21-26.
29. Symington A, Pinelli J. Developmental care for promoting development and preventing morbidity in preterm infants. *Cochrane Database Syst Rev*. 2006;2:CD001814.
30. Kristoffersen L, Stoen R, Rygh H, et al. Early skin-to-skin contact or incubator for very preterm infants: study protocol for a randomized controlled trial. *Trials*. 2016;17(1):593.
31. Lindberg B, Ohrling K. Experiences of having a prematurely born infant from the perspective of mothers in northern Sweden. *Int J Circumpolar Health*. 2008;67(5):461-471.
32. Korja R, Savonlahti E, Ahlqvist-Bjorkroth S, et al. Maternal depression is associated with mother-infant interaction in preterm infants. *Acta Paediatr*. 2008;97(6):724-730.
33. McManus BM, Poehlmann J. Parent-child interaction, maternal depressive symptoms and preterm infant cognitive function. *Infant Behav Dev*. 2012;35(3):489-498.
34. Karlsson V, Heinemann AB, Sjors G, Nykvist KH, Agren J. Early skin-to-skin care in extremely preterm infants: thermal balance and care environment. *J pediatr*. 2012;161(3):422-426.
35. Thukral A, Sankar MJ, Agarwal R, Gupta N, Deorari AK, Paul VK. Early skin-to-skin contact and breast-feeding behavior in term neonates: a randomized controlled trial. *Neonatology*. 2012;102(2):114-119.

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