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# Maternally administered interventions for preterm infants in the NICU: Effects on maternal psychological distress and mother–infant relationship

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ABSTRACT

Although studies have examined the effects of interventions focused on preterm infants, few studies have examined the effects on maternal distress (anxiety, depressive symptoms, post-traumatic stress symptoms, parenting stress) or parenting. This study examined the effects of the auditory–tactile–visual–vestibular (ATVV) intervention and kangaroo care (KC) on maternal distress and the mother–infant relationship compared to an attention control group.

240 mothers from four hospitals were randomly assigned to the three groups. Maternal characteristics in the three groups were similar: 64.1% of ATVV mothers, 64.2% of KC mothers, and 76.5% of control mothers were African American; maternal age averaged 26.3 years for ATVV mothers, 28.1 for KC mothers, and 26.6 for control mothers; and years of education averaged 13.6 for ATVV and KC mothers, and 13.1 for control mothers. Mothers only differed on parity: 68.4% of ATVV and 54.7% of KC mothers were first-time mothers as compared to 43.6% of control mothers. Their infants had a similar mean gestational ages (27.0 weeks for ATVV, 27.2 for KC, and 27.4 for control) and mean birthweights (993 g for ATVV, 1022 for KC, and 1023 for control).

Mothers completed questionnaires during hospitalization, and at 2, 6 and 12 months corrected age on demographic characteristics, depressive symptoms, state anxiety, post-traumatic stress symptoms, parenting stress, worry about child health, and child vulnerability (only at 12 months). At 2 and 6 months, 45-min videotapes of mother–infant interactions were made, and the HOME Inventory was scored. Behaviors coded from the videotapes and a HOME subscale were combined into five interactive dimensions: maternal positive involvement and developmental stimulation and child social behaviors, developmental maturity, and irritability.

Intervention effects were examined using general linear mixed models controlling for parity and recruitment site. The groups did not differ on any maternal distress variable.

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Kangaroo care mothers showed a more rapid decline in worry than the other mothers. The only interactive dimensions that differed between the groups were child social behaviors and developmental maturity, which were both higher for kangaroo care infants. Change over time in several individual infant behaviors was affected by the interventions. When mothers reported on the interventions they performed, regardless of group assignment, massage (any form including ATVV) was associated with a more rapid decline in depressive symptoms and higher HOME scores. Performing either intervention was associated with lower parenting stress. These findings suggest that as short-term interventions, KC and ATVV have important effects on mothers and their preterm infants, especially in the first half of the first year.



## 1. Introduction

Preterm infants' need for intensive care often leads to psychological distress in mothers (Kong et al., 2013; Miles, Holditch-Davis, Scher, & Schwartz, 2007). This distress may be due to the loss of the parental role during infant hospitalization and worry about infant health or survival and leads to heightened anxiety, depression, and post-traumatic stress (Holditch-Davis et al., 2009; McCabe et al., 2012; Lasiuk, Corneau, & Newburn-Cook, 2013; Rogers, Kidokoro, Wallendorf, & Inder, 2013). Maternal distress continues after the infant is discharged home, interfering with mother–infant interactions and infant development (Feeley et al., 2011; Gray, Edwards, O'Callaghan, & Cuskelly, 2012; Holditch-Davis et al., 2009; Lefkowitz, Baxt, & Evans, 2010). Interventions to address the early loss of maternal role, reduce psychological distress, and improve mother–infant interactions are needed (Lasiuk et al., 2013). Several studies have examined interventions that focus specifically on parents (e.g., Benzies, Magill-Evans, Hayden, & Ballantyne, 2013; Melnyk et al., 2006; Morey & Gregory, 2012; Ravn et al., 2012). Less is known about the degree to which interventions focused on the preterm infant might also affect mothers, especially when administered by mothers. This study compared the effects of two maternally administered interventions – the auditory, tactile, visual, and vestibular (ATVV) intervention and kangaroo care (KC) – that offer mothers a role in the care of their preterm infants. The effects of these interventions on maternal psychological distress and the mother–infant relationship were evaluated in comparison to an attention control group.

The in-hospital interventions in this study have been rigorously tested (Ludington-Hoe, Nguyen, Swinth, & Satyshur, 2000; White-Traut et al., 2013; White-Traut et al., 2002c). These interventions can be administered by mothers, thus providing an opportunity for mothers to have a role in the neonatal intensive care unit (NICU). However, little is known about maternal response to these interventions or their long-term outcomes.

Specifically, the auditory, tactile, visual, and vestibular (ATVV) intervention involves moderate stroking, eye contact with, talking to, and rocking the infant (Burns, Cunningham, White-Traut, Silvestri, & Nelson, 1994). ATVV tends to arouse infants (White-Traut et al., 1999; White-Traut et al., 2002c). It has resulted in positive infant outcomes including increased alertness before and after feedings, more rapid progression from gavage to complete oral feedings, better growth, increased responsiveness to mothers, and earlier hospital discharge than controls (Nelson et al., 2001; White-Traut et al., 1999; White-Traut, Schwertz, McFarlin, & Kogan, 2009; White-Traut & Tubeszewski, 1986).

The ATVV intervention and other forms of massage also positively affect mothers and the mother–infant relationship. Mothers who provided ATVV for their infants showed more positive interactive behaviors during feeding than comparison mothers (White-Traut & Nelson, 1988), and their infants had clearer behavioral cues and were more responsive to their mothers (White-Traut & Nelson, 1988; White-Traut et al., 2013). Preterm infants massaged by mothers or trained interveners interacted more positively with their mothers than comparison infants (Ferber et al., 2005). Massaging infants reduced maternal anxiety and depression (de Macedo, Cruvinel, Lukasova, & D'Antino, 2007; Feijo et al., 2006).

Kangaroo care involves holding the infant in skin-to-skin contact between the mother's breasts. KC was developed to warm the infant, involve the mother, and foster early home discharge in low resource countries. When mothers perform KC continuously around the clock in the hospital or at home, it is called kangaroo mother care. In developed countries, KC is not usually used as an alternative to hospitalization but as a way for preterm infants to have more contact during parental visits. Studies of intermittent KC have shown it to be safe: temperature, heart rate, respiratory patterns, and oxygenation remained stable or improved during KC as compared to incubator care or standard holding (Chwo et al., 2002; Karlsson, Heinemann, Sjörs, Nykvist, & Agren, 2012; Ludington-Hoe, Anderson, Swinth, Thompson, & Hadeed, 2004). During KC, infants exhibited more sleep (especially quiet sleep), less crying, more regular respiration, and more mature behavioral organization than when in the incubator (Chwo et al., 2002; Neu, Robinson, & Schmiege, 2013). KC has also been related to better head growth but not with greater weight gain (Ahn, Lee, & Shin, 2010; Roberts, Paynter, & McEwan, 2000). Studies using historical controls or allowing mothers to choose whether they provided KC found that infants receiving KC had more rapid maturation of sleep–wake states, more positive mood at 6 months, and better development through 2 years (Feldman & Eidelman, 2003; Feldman, Rosenthal, & Eidelman, 2014; Ohgi et al., 2002).

KC has also been shown to benefit mothers and the mother–infant relationship. Most mothers reported positive experiences with KC and preferred it to just holding the infant (Johnson, 2007; Mahmood, Jamal, & Khan, 2011; Neu, 2004), but some were anxious about dislodging medical tubing or harming the baby during KC, especially if the infant was

on mechanical ventilation (Gale, Franck, & Lund, 1993; Neu, 2004). In clinical trials, mothers who provided KC had less anxiety and fewer depressive symptoms and more positive interactions with their infants in the first 6 months than other mothers (de Macedo et al., 2007; Neu & Robinson, 2010). Mothers who chose to provide KC had less anxiety and depressive symptoms, showed more positive affect, were more sensitive and less intrusive, showed more attachment behaviors and had shorter latencies to joint attention with their infants than mothers not providing KC, and their infants were less negative and more alert (de Alencar, Arraes, de Albuquerque, & Alves, 2009; Feldman et al., 2014; Feldman, Weller, Sirota, & Eidelman, 2002; Feldman, Weller, Sirota, & Eidelman, 2003; Tallandini & Scalembra, 2006). Because the mothers were not randomly assigned but chose whether to provide KC, the two groups may have differed before the intervention. Other studies have not found an effect of KC on maternal depressive symptoms (Ahn et al., 2010), maternal stress about the NICU experience (Roberts et al., 2000), or mother–infant interactions (Chiu & Anderson, 2009).

Because ATVV and KC provide an opportunity for mothers to care for their infants in the NICU, we hypothesized that administering these interventions would address the early loss of the maternal role, reduce maternal distress, and improve the mother–infant relationship. The purpose of this study was to examine the effects of ATVV and KC on maternal psychological distress and the mother–infant relationship (infant responsiveness, maternal perceptions of the child indicated by worry and child vulnerability, mother–infant interactive dimensions, HOME total score) as compared to an attention control group. The developmental science perspective on the mother–infant dyad (Cairns, Elder, & Costello, 1996; Miles & Holditch-Davis, 2003; Thoman, Acebo, & Becker, 1983) was the theoretical framework. The preterm infant is in continuous, reciprocal interaction with the environment, particularly the mother (Thoman et al., 1983). Changes in the mother affect the infant as the mother–infant system is altered to maintain system equilibrium. For interventions to have a sustained impact on the mother–infant system, the mother as well as the infant must change. The two study interventions should have similar effects on the mother by supporting the maternal role in the NICU, leading to an improved mother–child relationship.

## 2. Methods

Using a three-group longitudinal design, mothers and infants were randomly assigned to ATVV, KC, or an attention control group and followed during hospitalization until 12 months of age corrected for prematurity. All time points for this study were infant corrected ages.

### 2.1. Setting

The sample was recruited from four hospitals, two in North Carolina (NC-A and NC-B) and two in Illinois (IL-A and IL-B). NC-A and NC-B were southern and served urban, suburban, and rural people of diverse socioeconomic status, whereas IL-A and IL-B served midwestern, inner city, and poor populations. The staff of these hospitals did not routinely encourage parents to massage their infants. Only NC-B encouraged mothers to use KC at the start of the study, and then not routinely. Over the course of the study, routine use of KC increased at all sites.

### 2.2. Participants

The participants were 240 preterm infants who weighed less than 1750 g at birth and their mothers. We excluded infants with congenital neurological problems or symptoms of substance exposure. All other infants, including those with postnatal neurological insults or substance exposure without symptoms, were eligible. Multiple birth infants were included, and one infant from each set was randomly selected for the study. Mothers were excluded if they did not have custody of the infant, if they had a risk factor that could affect their ability to administer the intervention (e.g., age less than 15; history of psychosis or bipolar disease; current major depression; or non-English speaking), or if follow-up for 12 months was unlikely.

Inclusion criteria were met by 458 mothers: 209 declined participation, and 249 agreed to be enrolled. Nine withdrew before providing data because of transfer to another hospital, infrequent visitation, or worsening of the infant's medical condition. Characteristics of the 240 mothers and infants are in Table 1. Data were compared among the groups using ANOVAs for continuous variables and Chi square analyses for categorical variables. The only difference was that there were fewer first-time mothers in the control group.

Table 2 shows the characteristics of the participants at the four hospitals. The sites differed on infant characteristics: gestational age at birth, birthweight, 1 and 5 min Apgar scores, number of neurological insults, length of mechanical ventilation, intraventricular hemorrhage, percent having surgery, percent with necrotizing enterocolitis, number of infections, and percent delivered by cesarean section. NC-A was a children's hospital that was a referral center for surgery; the infants at NC-A were smaller and sicker and had more medical complications and more surgeries than infants from the other hospitals. Some maternal variables also differed among the sites: mothers from the Illinois sites were more likely to be younger, unmarried, Black or Hispanic, not a first-time mother, less educated, and on public assistance than the North Carolina mothers.

### 2.3. Description of the interventions

Three groups were studied: one administered White-Traut's ATVV intervention to their preterm infants (Burns et al., 1994; White-Traut et al., 1999), the second administered kangaroo care using the protocol of Ludington-Hoe et al. (1999),

**Table 1**
Demographic characteristics of the entire sample and of ATVV, kangaroo care, and control groups at enrollment.

| | | Control | | ATVV | | Kangaroo care | | Total sample | |
|---|---|---|---|---|---|---|---|---|---|
| | | *N* | Mean (SD) | *N* | Mean (SD) | *N* | Mean (SD) | *N* | Mean (SD) |
| Gestat. age (weeks) | | 81 | 27.4 (3.1) | 78 | 27.0 (2.8) | 78 | 27.2 (2.9) | 237 | 27.2 (2.9) |
| Birthweight (g) | | 81 | 1023.0 (343) | 77 | 992.8 (329) | 78 | 1021.7 (317) | 236 | 1012.8 (329) |
| % Male | | 81 | 46.9% | 78 | 46.2% | 78 | 46.2% | 237 | 46.4% |
| Size | % AGA | 81 | 80.3% | 76 | 84.2% | 78 | 78.2% | 235 | 80.9% |
| | % LGA | | 1.2% | | 0.0% | | 3.9% | | 1.7% |
| | % SGA | | 18.5% | | 15.8% | | 18.0% | | 17.5% |
| Apgar | 1 Min. | 81 | 5.3 (2.4) | 76 | 4.8 (2.7) | 78 | 5.0 (2.5) | 235 | 5.1 (2.5) |
| score | 5 Min. | 80 | 7.4 (1.6) | 76 | 7.2 (1.7) | 78 | 7.1 (1.8) | 234 | 7.2 (1.7) |
| Neurological insults[a] | | 81 | 3.6 (3.6) | 76 | 4.2 (3.8) | 78 | 4.4 (4.2) | 235 | 4.1 (3.9) |
| Mech. Ventil. (days) | | 81 | 15.0 (19.9) | 77 | 19.3 (37.1) | 78 | 14.8 (18.6) | 236 | 16.3 (26.4) |
| IVH | None | 81 | 67.9% | 76 | 72.4% | 78 | 61.5% | 235 | 67.2% |
| | % Grade I | | 16.1% | | 15.8% | | 19.2% | | 17.0% |
| | % Grade II | | 11.1% | | 2.6% | | 6.4% | | 6.8% |
| | % Grade III | | 0.0% | | 1.3% | | 2.6% | | 1.3% |
| | % Grade IV | | 4.9% | | 7.9% | | 10.3% | | 7.7% |
| % Having surgery | | 80 | 40.0% | 76 | 31.6% | 78 | 37.2% | 234 | 36.3% |
| % Multiple births | | 81 | 16.1% | 77 | 19.5% | 78 | 18.0% | 236 | 17.8% |
| % PDA | | 81 | 44.4% | 78 | 44.9% | 81 | 39.5% | 240 | 42.9% |
| % NEC | | 80 | 16.3% | 76 | 11.8% | 78 | 18.0% | 234 | 15.4% |
| No. of infections | | 81 | 1.8 (1.5) | 76 | 1.9 (1.8) | 78 | 1.8 (1.6) | 235 | 1.8 (1.6) |
| % Cesarean section | | 81 | 58.0% | 78 | 62.3% | 81 | 54.3% | 239 | 58.2% |
| Maternal age | | 80 | 26.8 (6.5) | 78 | 26.3 (5.5) | 77 | 28.1 (6.1) | 234 | 27.1 (6.1) |
| Race | White | 81 | 17.3% | 78 | 21.8% | 81 | 18.5% | 240 | 19.2% |
| | Black | | 76.5% | | 64.1% | | 64.2% | | 68.3% |
| | Hispanic | | 4.9% | | 10.3% | | 9.9% | | 8.3% |
| | Other | | 1.2% | | 3.9% | | 7.4% | | 4.2% |
| % Mothers married | | 80 | 26.3% | 77 | 37.7% | 74 | 32.4% | 231 | 32.0% |
| % 1st-time mothers[*] | | 78 | 43.6% | 76 | 68.4% | 75 | 54.7% | 229 | 55.5% |
| Maternal Ed. (years) | | 77 | 13.1 (2.2) | 76 | 13.6 (2.0) | 74 | 13.6 (2.5) | 227 | 13.4 (2.3) |
| % On public Assist. | | 80 | 22.5% | 77 | 19.5% | 77 | 19.5% | 234 | 20.1% |

*Note*: Gestation. = gestational; AGA = average for gestational age; LGA = large for gestational age; SGA = small for gestational age; Min. = minute; Mech. Ventil. = mechanical ventilation; IVH = intraventricular hemorrhage; PDA = patent ductus arteriosis; NEC = necrotizing enterocolitis; Ed. = education; Assist. = assistance.

[a] Scored on Neurobehavioral Risk Scale (Brazy et al., 1993).

[*] Groups differ, $p < 0.01$.

and the third was an attention control group. Mothers were asked to use the intervention in the NICU and continue it at home until the infant was 2 months corrected age. ATVV and KC are safe to perform after hospital discharge, and many mothers do so (Neu, 2004; White-Traut et al., 2004).

### 2.3.1. *Multi-sensory ATVV intervention*

ATVV involved presenting stimulation in a gradual progression over 15 min, beginning with auditory only (voice), then auditory and tactile (moderate stroking or massage), with visual stimulation (eye-to-eye) added as the infant becomes alert (Burns et al., 1994). Horizontal rocking was added, and the tactile component withdrawn, for the final 5 min. The tactile stimuli proceeded from the least to the most sensitive areas and included moderate stroking of the top and back of the infant's head, back, chest, abdomen, arms, legs, and forehead. Eye-to-eye contact was provided when the infant was alert. We instructed mothers to discontinue ATVV if bradycardia, apnea, color changes, or distress occurred (Burns et al., 1994). Mothers were told to perform ATVV before feedings because it increases feeding readiness (White-Traut et al., 2002b).

### 2.3.2. *Kangaroo care intervention*

KC involved holding the infant in skin-to-skin contact in an upright position between the mother's breasts. The infant is dressed only in a diaper and hat, and the side of the infant not in contact with the mother is covered. During KC, the infant usually sleeps but may suck or feed at the breast (Ludington-Hoe et al., 1999). Mothers were instructed to do KC for as long as they wanted but for at least 15 min., and to stop it if the infant's temperature fell or if apnea or bradycardia occurred.

**Table 2**
Demographic characteristics of the preterm infants and their mothers at each recruitment hospital at enrollment.

| | | NC-A | | NC-B | | IL-A | | IL-B | |
|---|---|---|---|---|---|---|---|---|---|
| | | *N* | Mean (SD) | *N* | Mean (SD) | *N* | Mean (SD) | *N* | Mean (SD) |
| Gestat. age (weeks)** | | 34 | 25.6 (2.3) | 90 | 26.7 (2.5) | 80 | 28.6 (3.3) | 33 | 27.2 (2.5) |
| Birthweight (g)** | | 34 | 826.4 (289) | 89 | 1008.0 (301) | 80 | 1081.8 (364) | 33 | 1036.5 (284) |
| Sex of child: % Male | | 34 | 47.1% | 90 | 47.8% | 80 | 45.0% | 33 | 45.5% |
| Size | % AGA | 34 | 88.2% | 89 | 77.5% | 80 | 76.3% | 32 | 93.8% |
| | % LGA | | 0.0% | | 4.5% | | 0.0% | | 0.0% |
| | % SGA | | 11.8% | | 18.0% | | 23.8% | | 6.3% |
| Apgar | 1 Min.** | 34 | 4.1 (2.8) | 88 | 4.4 (2.4) | 80 | 5.5 (2.5) | 33 | 6.6 (1.4) |
| score | 5 Min.** | 33 | 6.3 (2.4) | 88 | 7.0 (1.6) | 80 | 7.7 (1.3) | 33 | 7.8 (1.0) |
| Neurological insults**,[a] | | 33 | 8.2 (4.7) | 89 | 3.7 (3.6) | 80 | 3.3 (3.2) | 33 | 3.0 (2.8) |
| Mech. Vent. (days)** | | 34 | 43.3 (52.6) | 89 | 10.2 (11.8) | 80 | 14.1 (11.8) | 33 | 10.6 (14.0) |
| IVH* | None | 33 | 48.5% | 89 | 58.4% | 80 | 76.3% | 33 | 87.9% |
| | % Grade I | | 18.2% | | 24.7% | | 13.8% | | 3.0% |
| | % Grade II | | 12.1% | | 7.9% | | 5.0% | | 3.0% |
| | % Grade III | | 3.0% | | 1.1% | | 1.3% | | 0.0% |
| | % Grade IV | | 18.2% | | 7.9% | | 3.8% | | 6.1% |
| % Having surgery*** | | 33 | 78.8% | 89 | 39.3% | 79 | 21.5% | 33 | 21.2% |
| % Multiple births | | 34 | 20.6% | 89 | 23.6% | 80 | 12.5% | 33 | 12.1% |
| % PDA | | 34 | 58.8% | 91 | 39.6% | 81 | 45.7% | 34 | 29.4% |
| % NEC*** | | 33 | 54.6% | 88 | 12.5% | 80 | 6.3% | 33 | 6.1% |
| No. of infections** | | 33 | 3.1 (2.1) | 89 | 1.8 (1.4) | 80 | 1.5 (1.4) | 33 | 1.4 (1.4) |
| % Cesarean section** | | 33 | 75.8% | 91 | 65.9% | 81 | 46.9% | 34 | 47.1% |
| Maternal age** | | 34 | 27.7 (6.9) | 89 | 29.5 (5.9) | 80 | 24.9 (5.1) | 32 | 25.2 (5.4) |
| Race*** | White | 34 | 55.9% | 91 | 25.3% | 81 | 2.5% | 34 | 5.9% |
| | Black | | 41.2% | | 68.1% | | 77.8% | | 73.5% |
| | Hispanic | | 2.9% | | 1.1% | | 16.1% | | 14.7% |
| | Other | | 0.0% | | 5.5% | | 3.7% | | 5.9% |
| % Mothers married** | | 34 | 50.0% | 89 | 46.1% | 77 | 16.9% | 31 | 9.7% |
| % First-time mothers | | 25 | 72.0% | 91 | 58.2% | 80 | 53.8% | 33 | 39.4% |
| Maternal Ed. (years)** | | 33 | 13.6 (2.2) | 87 | 14.3 (2.6) | 77 | 12.6 (1.7) | 30 | 12.8 (1.5) |
| % Public Assist.*** | | 34 | 2.9% | 89 | 3.4% | 79 | 38.0% | 32 | 40.6% |

*Note*: Gestation. = gestational; AGA = average for gestational age; LGA = large for gestational age; SGA = small for gestational age; Min. = minute; Mech. Vent. = mechanical ventilation; IVH = intraventricular hemorrhage; PDA = patent ductus arteriosis; NEC = necrotizing enterocolitis; Ed. = education; Assist. = assistance.

[a] Scored on Neurobehavioral Risk Scale (Brazy et al., 1993).

* Hospitals differ, $p < 0.05$.

** Hospitals differ, $p < 0.01$.

*** Hospitals differ, $p < 0.001$.

### 2.3.3. *Attention control intervention*

The third group spent a similar time as the intervention mothers with the study nurse discussing how to select and locate safe equipment needed to care for preterm infants at home. Specific topics included diapers, infant clothing and blankets, car seats, breastfeeding supplements, formula, and toys. Since the intervention groups saw their study nurse once a week, the control mothers did as well.

### 2.3.4. *Intervention procedures*

After enrollment, the study nurse instructed mothers in their assigned intervention using a protocol developed for the study and gave them written handouts. Mothers were asked not to discuss their intervention with other parents. Intervention mothers met in the presence of the baby so that they could practice. They were asked to visit as often as possible (preferably daily) but at least three times a week and spend at least 15 min. doing the intervention. To insure safety, mothers were told not to perform interventions while infants were on mechanical ventilation or continuous positive airway pressure. Most mothers learned the intervention in an hour.

The study nurse met with mothers weekly whenever possible. Mothers were videotaped administering their intervention, the nurse corrected any aspect that was performed incorrectly, and the mother's questions were answered. Control mothers were videotaped holding their infants to keep their time with the nurse comparable to the intervention groups. Videotapes were used in supervision to ensure that the study nurses were effectively educating mothers. Videotapes were also scored for sleep–wake states after 15 min of ATVV or KC. Since holding was not part of the control condition, videotapes of control infants were not scored.

Nurses in the NICUs were instructed in the protocols for all three groups so that they could care for and monitor infants. They were instructed to interact with mothers as usual and not to instruct the mothers on the interventions or express a preference for any intervention. Instead, they should wait for mothers' questions or requests for help. The fact that an infant was enrolled in the study, but not the group assignment, was posted on the infant's bedside.

#### 2.3.5. Tracking intervention activities

Field notes were written by the study nurse after each contact. Each mother was asked to complete a visit diary for each hospital visit by checking the activities in which she engaged. Mothers were told that the diary listed activities of mothers during visits but that no mother was expected to do all of them. The checklist included kangaroo care and infant massage (since the other groups were not familiar with the term ATVV) as well as several distractors (e.g., holding, feeding, touching, changing, bathing). This diary was used to determine in which interventions the mother actually engaged. For secondary analyses, mothers were classified based on their use of each intervention regardless of assigned group: no intervention, massage (and ATVV) only, kangaroo care only, or both.

#### 2.3.6. Training and supervision of the study nurses

The investigators provided more than 20 h of training that included study goals and design, discussions of intervention strategies, and ways to recognize when the infant was not tolerating an intervention. The first intervention contact for each study nurse was done jointly with an investigator or experienced study nurse. During bi-weekly teleconferences between the North Carolina and Illinois sites, field notes and hospital videotapes were reviewed, experiences with the mothers were discussed, and investigators insured that the study nurses were following protocols.

### 2.4. Variables

#### 2.4.1. Infant sleep–wake responses to the intervention

To determine whether infants showed typical sleep–wake responses to the interventions (alertness after ATVV and increased quiet sleep during KC), arousal was scored for 5 min from the videotapes. The predominant sleep–wake state (alertness, drowsiness, active waking, sleep–wake transition, active sleep, and quiet sleep) was recorded once a minute following ATVV and beginning 15 min after the start of KC. The presence of any amount of alertness was also scored. The scorers used the sleep–wake codes that Holditch-Davis used in several studies and that show reliable individual differences (Holditch-Davis & Edwards, 1998; Holditch-Davis, Scher, Schwartz, & Hudson-Barr, 2004). Each tape was scored by two coders; if they did not agree 100%, Holditch-Davis scored. Coders inevitably were aware of group membership, but most were not involved with other aspects of the study, and videotapes were scored after all contacts with the family were complete.

#### 2.4.2. Maternal psychological distress

Four types of maternal psychological distress were studied: depressive symptoms on the Center for Epidemiologic Studies Depression Scale (CESD; Radloff, 1977), anxiety on the state anxiety sub-scale of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorusch, Lushene, Vagg, & Jacobs, 1983), post-traumatic stress symptoms on the Perinatal PTSD Questionnaire (PPQ; Callahan & Hynan, 2002; Quinnell & Hynan, 1999), and parenting stress on the Parental Stress Scale: Prematurely Born Child (PSS:PBC). Scores of mothers of preterm infants on these instruments were related to other indicators of psychological distress, including hospital environmental stress and worry about the child's health, and to each other (Holditch-Davis et al., 2009; Miles et al., 2007). Scores on the PPQ correlated with scores on general PTSD scales (which are not specific to perinatal events) and the severity of infant perinatal complications (DeMier et al., 2000; Quinnell & Hynan, 1999). In this sample, Cronbach's alphas for the CESD ranged from .86 at 12 months to .90 at enrollment, for the STAI ranged from .88 at 2 months to .93 at enrollment, for the PPQ ranged from .79 at enrollment, to .86 at 6 months, and for the PSS:PBC were .91 at 2 and 6 months and .90 at 12 months.

#### 2.4.3. The mother–infant relationship

The mother–child relationship was measured by infant responsiveness to stimulation at hospital discharge, maternal perceptions of the infant (worry about child health and child vulnerability), videotapes of mother–infant interactions, and the HOME Inventory. Infant responsiveness was measured using the six orientation items from the Neonatal Behavioral Assessment Scale (NBAS; Brazelton, 1984). Items were administered and scored as outlined in the NBAS manual. All items are scored on a 1-to-9 scale, with 1 as the worst performance. In this sample, internal consistency of the total scale was .89, inanimate responsiveness subscale was .81, and animate responsiveness was .82.

The worry index (Miles & Holditch-Davis, 1995) measured how much mothers worried about their infant and the child's risk for health problems. Items are rated on a 5-point scale. Worry scores of mothers of preterm infants were related to depressive symptoms and to parenting (Holditch-Davis et al., 2009; Holditch-Davis, Schwartz, Black, & Scher, 2007; Miles et al., 2007). Internal consistency in this study ranged from .88 at enrollment to .83 at 2 months.

The Vulnerable Child Scale measured the mother's perception of her child's vulnerability to health problems (Perrin, West, & Culley, 1989). This questionnaire deals with toddlers so it was scored only at 12 months. The tool consists of 16

items that mothers rated on a 4-point scale. Item scores are summed. Total scores range from 16 to 64 with lower scores indicating a greater sense of vulnerability. Cronbach's alpha was .80 in the current study.

At 2 and 6 months corrected age, a 45-min videotape of mother–infant interactions was made at a time when the infant was awake and due for a feeding. Mothers were told that the goal was to record child and mother behaviors when home together and to care for the infant as though the videotaper were not present. Research assistants masked to group membership coded videotapes with a proven coding system (Holditch-Davis et al., 2007; Holditch-Davis, Miles, Burchinal, & Goldman, 2011). Maternal and child behaviors (e.g., talking, touching, playing) were coded every 10 s. Inter-rater reliability was checked every other month; kappas for the variables in this report ranged from 0.64 to 0.99 with a mean of 0.86.

The coded mother and infant behaviors variables were measured as a percentage of the total videotape. Definitions of these behaviors have been published (Holditch-Davis et al., 2007; Holditch-Davis, Bartlett, & Belyea, 2000a). Child activity level variables (asleep, sedentary activity, moderate activity, very active) summed to 100%. Also, child negative was measured as a percentage of time the mother was together with the child and play with objects was measured as a percentage of the time that the child was not playing with the mother. Eight maternal and seven infant variables were used in the maternal and child dimensions. Mother touch, interaction, talk, involvement with child, positive affect, teaching, touch, and playing with the child were included since they are related to child development (Holditch-Davis et al., 2000a; Olsen, Bates, & Kaskie, 1992). Child expression of negative and positive affect, independent play with objects, locomotion, gesturing, and vocalization were used as these variables have been shown to indicate infant maturity or to be affected by maternal depression (Field et al., 1996; Holditch-Davis, Cox, Miles, & Belyea, 2003; Miles et al., 2007).

The HOME inventory (0–3 version) measured the social-emotional and stimulation characteristics of the home environment (Caldwell & Bradley, 1980). The total score is the number of present items range 0 to 45), with higher scores indicating better environments. The HOME was scored after the videotaping, using information about the home gained during the videotaping, but only 8 of the 45 HOME items could be directly scored from interaction codes. The HOME is correlated with child cognitive abilities (Bradley et al., 1994; Holditch-Davis et al., 2000b) and with the behaviors of mothers and children during observations (Holditch-Davis et al., 2000b; Tesh & Holditch-Davis, 1997). The HOME total score was analyzed, and one subscale – maternal involvement – was used in the maternal dimensions. The HOME total had an alpha of .84 at 2 months and .83 at 6 months; the maternal involvement subscale had alphas of .70 at 2 and 6 months.

Eight maternal behaviors and the maternal involvement sub-scale from the HOME were grouped into two theoretically derived maternal dimensions. Seven child behaviors were grouped into three theoretically derived child dimensions (Holditch-Davis et al., 2007; Lee, Holditch-Davis, & Miles, 2007). To calculate dimension scores, each variable was converted to *Z*-scores based on the combined 2- and 6-month data, and the *Z*-scores for the variables in each dimension were averaged. Thus, age-related differences in dimensions were maintained. Maternal positive involvement included mother positive, touch, hold, interaction, uninvolved with child (reversed), play with child, and the maternal involvement sub-scale and had internal consistency of .78. Developmental stimulation (mother talk, teach) had a Cronbach's alpha of .69. Child social behaviors (child express positive affect, gesture) had an alpha of .68. Developmental maturity included child vocalize, independent play with objects, and locomote and had an alpha of .58. Child irritability (child negative, fuss as a percent of time with the mother) had an alpha of .91.

#### *2.4.4. Covariates and descriptive variables*

Mothers completed a demographic questionnaire at every contact. This questionnaire asked for the age, race, ethnicity, education, and occupation of the mother, spouse, head of household, people living in the house with the child, their ages and relationships to the child, and whether or not the family was receiving public assistance. Infant medical records were reviewed weekly until discharge. To determine the severity of potential neurologic insults, medical record data was scored on the Neurobiologic Risk Scale (NBRS; Brazy, Goldstein, Oehler, Gustafson, & Thompson, 1993) that measured potential insults to the brain through direct injury or inadequate nutrients and is correlated with the Bayley MDI and PDI at 6–24 months corrected age. Cronbach's alpha was .71 in the current study.

### *2.5. Procedures*

Infants and mothers were recruited when the infant was no longer critically ill and weighed at least 1000 g to reduce the risk of hypothermia during holding. To exclude infants who remain chronically critically ill and thus are at high risk for atypical interactions and prolonged maternal emotional distress (Holditch-Davis et al., 2000a; Miles, Holditch-Davis, Burchinal, & Nelson, 1999), infants who remained hospitalized longer than 1 month after term were withdrawn from the study. Once a mother provided informed consent, baseline questionnaires were administered, and she was instructed on completion of the visit diary.

Infant–mother dyads were assigned to the intervention and control groups using a random schedule predetermined by the statistician. Randomization was stratified based on recruitment site and on singletons vs. multiple births using a block size of six so that similar percentages of infants from each site and multiple births were in each group. The study nurse informed the mother of her group and scheduled a meeting within a week to teach her this intervention.

To mask the data collectors and videotape scorers to group assignment and prevent subject response bias due to familiarity with the study nurse, the study staff was divided into two teams. The study nurses were in charge of recruitment, chart reviews, group assignments, and intervention delivery. The assessment team was responsible for questionnaires,

assessments of the mother–child relationship, and scoring of videotapes. Mothers had a data collection contact at hospital discharge and home visits at 2 and 6 months corrected for prematurity. At all contacts, the mother completed questionnaires. Also, at 2 and 6 months, mother–infant interactions were videotaped and the HOME inventory was scored. At 12 months, data was collected at the neonatal follow-up clinics of the study hospitals or by a study-employed psychologist in the subject's home.

Providing incentives for research subjects is standard practice in the United States so mothers were paid $10 for each contact at which they completed questionnaires and for each week they completed a Visit Diary. Mothers were reimbursed for travel to the clinic at the 12-month contact and paid $20 for incidental expenses (lunch, parking, etc.). The infant was given a small gift at each home visit; at 2 months, the mother was given a DVD of her in-hospital sessions; and at the end of the study, she was given a DVD of her home interaction sessions.

### 2.6. Data analyses

The intervention and control groups were compared using intent-to-treat analyses, in which each mother–infant dyad was analyzed in the group that the dyad was assigned. Missing data were assumed to be missing at random, and no imputation methods were used, with one exception. If at least 75% of a scale's items were non-missing, then values for missing items were imputed using the mean of the other items. Infant responsiveness and the Vulnerable Child Scale were measured at only one time point so they were analyzed using a general linear model.

The longitudinal analyses (sleep–wake states the intervention, depressive symptoms, state anxiety, post-traumatic stress symptoms, parenting stress, worry, mother–infant interactive dimensions, HOME total) used the general linear mixed model (mixed model; Holditch-Davis, Edwards, & Helms, 1998; Holditch-Davis & Levy, 2010). Parameterization of the mixed model includes population (fixed) effects while calculating individual (random) effects, using SAS Proc Mixed. Preliminary analyses found no significant interactions between group and site (differential effects of the intervention at different sites) so this interaction was not included in analyses. Group, time (corrected age), time squared (quadratic effects of time), and interaction of group with time and time squared, parity, and recruitment site were used as the predictors. Time squared effects and interactions were only examined if the variable was obtained at four or more time points. Parity, site, time squared, and interactions were removed from each model if non-significant in a preliminary analysis.

## 3. Results

A total of 81 mother infant–dyads were randomized to the control group, 78 dyads to ATVV, and 81 to KC. Enrollment contacts were obtained on these dyads. One hundred and ninety-four dyads had endpoint data at either or both 6 and 12 months: 28 dyads withdrew by 2 months (before the completion of the intervention), 9 infants died (2 after completion of the intervention), and 9 were lost to follow-up after 2 months. The groups did not differ on these measures.

The dyads who left the study were compared with dyads who completed it on all of the mother and infant characteristics in Table 1 and enrollment depressive symptoms, anxiety, and post-traumatic stress symptoms using Chi square tests for categorical variables and general linear models for continuous variables. Most variables did not differ between these groups. Mothers who left the study were significantly more likely to be single (24.8% of single mothers) than mothers who completed it (16.2%) and to be younger (mean 25.3 years for withdrawals vs. 27.6 for completers). At enrollment, they had higher depressive symptoms (mean of 20.3 vs. 15.7 for completers) and anxiety (mean of 44.4 vs. 39.9) and but not post-traumatic stress symptoms. Although none of the infant health variables differed between the groups, boys were significantly more likely to leave the study than girls (29.1% of boys withdrew vs. 18.1% of girls). Dyads from hospital NC-B were significantly more likely to complete the study (86.8%) than dyads from the other three hospitals (64.7–71.6%).

### 3.1. Intervention dosage

Mothers differed in the amount of contact they had with the study nurse. Fifteen mothers were not instructed in their intervention, and most withdrew from the study by hospital discharge. The rest received at least complete instruction in the intervention (1 contact) or instruction plus return contacts (2 or more). Sixteen had 4 or more contacts with the study nurse.

Diaries on the use of interventions during hospital visits were completed by 150 mothers. The only difference from mothers who did not complete the diaries was that North Carolina mothers were more likely to complete diaries than Illinois mothers. Most intervention mothers engaged exclusively in their assigned intervention, with only 30% of the ATVV mothers and 22% of KC mothers reporting doing the other intervention, and all but 13% of KC mothers did so infrequently (less than once a week). On the other hand, 58% of control mothers reported using a form of massage (not trained in ATVV), KC, or both, but only 25% did so frequently.

### 3.2. Sleep–wakes states

Table 3 shows the comparison of sleep–wake states between the ATVV and KC infants after 15 min of the intervention. ATVV infants had significantly more alert, total waking, and total alertness and less active sleep, quiet sleep, and total sleeping. Thus, the interventions were having the expected effects on sleep–wake states. The only covariate that was significant was site for active sleep because infants from NC-A had the most active sleep, infants from IL-A the second most, infants from NC-B were third, and infants from IL-B the least.

### 3.3. Infant responsiveness

The effect of ATVV and KC on infant responsiveness to stimuli at the time of hospital discharge was examined using the NBAS orientation items (see Table 4). Although KC infants showed somewhat lower means on all three sub-scales, the differences were small and non-significant. Site had a significant effect on all variables because infants at the North Carolina sites were more responsive than infants at the Illinois sites.

**Table 3**
Results of comparing ATVV and kangaroo care on the predominant sleep–wake states during the first 5 min after 15 min of ATVV and kangaroo care.

| Sleep–wake state | ATVV | Kangaroo care | Intervention | Age | Site |
|---|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | $F(1,157)$ [c] | $F(1, 157)$ [c] | $F(3, 153)$ |
| Alert | 19.2 (34.3) | 4.5 (17.7) | 11.83*** | 1.79 | |
| Sleep–wake transition | 4.1 (9.6) | 2.6 (11.3) | 0.69 | 0.59 | |
| Active sleep | 35.3 (40.0) | 56.3 (43.1) | 6.94** | 0.75 | 2.91* |
| Quiet sleep | 12.9 (30.2) | 26.6 (39.3) | 5.46* | 0.00 | |
| Total waking | 46.3 (44.5) | 10.0 (27.2) | 39.67*** | 2.62 | |
| Total sleeping[b] | 49.5 (43.0) | 87.8 (30.4) | 41.90*** | 3.32 | |
| Total alertness[a] | 31.9 (42.1) | 6.6 (21.4) | 24.12*** | 1.04 | |

[a] Includes 1-min periods when alertness occurred but was not the predominant state.
[b] Includes periods when the infant was sleeping but because of visibility the specific sleep state could not be scored.
[c] Degrees of freedom are 1,153 for active sleep.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

**Table 4**
Comparisons of the infants in the three groups on mean responsiveness at the time of hospital discharge.

| | Control | ATVV | Kangaroo | Intervention | Site |
|---|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | Mean (SD) | $F(2, 189)$ | $F(3, 189)$ |
| Inanimate orientation | 4.46 (1.63) | 4.34 (1.65) | 4.02 (1.42) | 1.45 | 23.71*** |
| Animate orientation | 5.05 (1.40) | 5.06 (1.56) | 4.68 (1.40) | 1.72 | 18.35*** |
| All Orientation | 4.76 (1.42) | 4.71 (1.50) | 4.37 (1.32) | 1.81 | 25.25*** |

*** $p < 0.001$.

### 3.4. Maternal psychological distress

General linear models indicated that no maternal psychological distress variable differed among the groups at enrollment. Table 5 shows the longitudinal effects of the interventions on these variables. KC, ATVV, and control mothers did not differ on depressive symptoms, state anxiety, post-traumatic stress symptoms, or parenting stress. Time and time squared effects indicated that depressive symptoms, state anxiety, and post-traumatic stress symptoms decreased over time and the rate of decrease slowed over time. Parenting stress was measured at only three time points so only the linear effect of time was examined and showed a decrease over time. The study sites differed only on post-traumatic stress (mothers from Illinois reported less than North Carolina mothers), and parity did not have any significant effects.

These analyses were repeated for mother reported intervention usage, and significant effects of the interventions on maternal distress were found. Mothers who only did a form of massage (that included ATVV) had a more rapid decline in depressive symptoms that leveled out earlier than mothers not in engaging in any intervention (usage × time—$t$ (453) = 2.49, $p < 0.05$; usage × time squared—$t$ (453) = 2.43, $p < 0.05$); mothers doing KC only or both interventions did not differ from mothers not engaging in any intervention. Parenting stress was lower for mothers who engaged in any intervention than those who did not (a form of massage only—$t$ (195) = −3.33, $p < 0.001$; KC only—$t$ (195) = −2.90, $p < 0.01$; both—$t$ (195) = −2.66, $p < 0.01$).

### 3.5. Maternal perceptions of the infant

Table 5 also shows the effects of the interventions on perceptions of the child. KC mothers showed a more rapid and non-linear decline in worry than the ATVV or control mothers though the overall interaction of time squared × intervention did not reach significance. The time and time squared effects indicated that worry decreased over time and the rate of decrease slowed over time. The site effect was due to mothers at IL-B averaging the lowest amount of worry and mothers at NC-A (the children's hospital) the highest amount. The groups did not differ on the Child Vulnerability Scale score ($F(2, 161) = 0.09$), and no covariate was related to this score. These analyses were repeated with mother reported usage data with similar results.

### 3.6. Maternal–infant interactive dimensions

Next, we examined the longitudinal effects of intervention on maternal infant-interactions at 2 and 6 months (see Table 6). Maternal positive involvement, developmental stimulation, and the HOME total score did not differ between the groups. Positive involvement decreased and the HOME total score increased with age. Mothers from the Illinois hospitals exhibited lower scores on positive involvement, developmental stimulation, and the HOME than the North Carolina mothers. First time mothers had more positive involvement, more developmental stimulation, and higher HOME scores.

Child irritability did not differ between the groups. Social behaviors and developmental maturity increased with age, and child irritability decreased. For social behaviors, although the overall intervention effect was significant, neither ATVV nor KC differed from the control group. ATVV infants had the lowest amount of social behaviors, KC the highest, and control infants intermediate amounts. The time × intervention interaction for social behaviors was due to KC infants having a slower increase over age than infants in the other groups. Intervention and time × intervention effects for developmental maturity was due to KC infants showing more mature behaviors but a slower increase over age than the infants in the other two groups. Infants of first-time mothers exhibited significantly more developmental maturity than later born infants.

Analyses were repeated for the interventions that mothers reported using, and similar findings were obtained except for the HOME. Mothers who performed either a form of massage (including ATVV) or both interventions had higher HOME scores than mothers who engaged in neither (massage only—$t$ (92) = 2.51, $p < 0.05$; both—$t$ (92) = 2.62, $p < 0.05$). HOME scores were also higher for mothers who only performed KC, but this was not significant ($t$ (92) = 1.86, $p = 0.07$).

**Table 5**
Comparison of the three intervention groups on maternal psychological distress variables and on worry about child health through 12 months.

| Parameter | Depressive symptoms | | State anxiety | | Post-traumatic stress | |
|---|---|---|---|---|---|---|
| | Estimate (SE) | $t$ (686)[a] | Estimate (SE) | $t$ (689)[a] | Estimate (SE) | $t$ (685)[a] |
| Intercept | 14.35 (0.92) | 15.61*** | 35.23 (0.97) | 36.32*** | 4.40 (0.39) | 11.41*** |
| Intervention | *F(2, 686) = 0.74* | | *F(2, 689) = 0.32* | | *F(2, 685) = 0.08* | |
| ATVV | −0.85 (1.32) | −0.64 | 0.09 (1.40) | 0.06 | −0.17 (0.45) | −0.38 |
| KC | −1.60 (1.31) | −1.21 | −0.94 (1.40) | −0.67 | 0.05 (0.45) | −0.10 |
| Time | −0.28 (0.03) | −8.21*** | −0.47 (0.04) | −11.50*** | −0.08 (0.01) | −7.76*** |
| Time squared | 0.004 (0.001) | 5.88*** | 0.01 (0.001) | 9.63*** | 0.001 (0.000) | 5.22*** |
| Time × Interv | *F(2, 686) = 0.86* | | *F(2, 689) = 0.43* | | *F(2, 685) = 0.56* | |
| Time × ATVV | 0.01 (0.03) | 0.38 | 0.02 (0.03) | 0.67 | 0.006 (0.008) | 0.07 |
| Time × KC | 0.04 (0.03) | 1.28 | −0.12 (0.09) | 0.88 | 0.008 (0.009) | 0.96 |
| Site | | | | | *F(3, 685) = 4.42*** | |

| | Parenting stress | | Worry about child health | |
|---|---|---|---|---|
| | Estimate (SE) | $t$ (275)[a] | Estimate (SE) | $t$(690)[a] |
| Intercept | 35.81 (1.45) | 24.75*** | 19.06 (0.82) | 23.35*** |
| Intervention | *F(2, 275) = 0.18* | | *F(2, 690) = 0.49* | |
| ATVV | 0.70 (2.40) | 0.29 | −0.92 (0.95) | −0.97 |
| KC | −0.75 (2.35) | −0.32 | −0.60 (3.95) −0.63 | |
| Time | −0.04 (0.03) | 8.12** | −0.19 (0.03) | −5.58* |
| Time squared | | | 0.002 (0.001) | 3.44*** |
| Time × Interv | *F(2, 275) = 1.44* | | *F(2, 690) = 3.96** | |
| Time × ATVV | −0.07 (0.05) | −1.35 | −0.002 (0.05) | −0.05 |
| Time × KC | 0.01 (0.05) | 0.26 | −0.13 (0.05) | −2.49* |
| Time squared × Interv | | | *F(2, 690) = 2.95*# | |
| Time squared × ATVV | | | −0.0001 (0.001) | −0.08 |
| Time squared × KC | | | 0.002 (0.001) | 2.09* |
| Site | | | *F(3, 690) = 4.85*** | |

[a] For the intercept, the $t$-test had 228 df for depressive symptoms and state anxiety, 225 df for post-traumatic stress symptoms, 195 df for parenting stress, and 225 df for worry.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
# $p < 0.06$.

### 3.7. Specific infant behaviors

Developmental maturity was made up of vocalization, locomotion, and independent play so we examined these variables separately using mixed models. Three activity level variables were also examined – sleep, sedentary activity, and moderate activity – because of the close association between activity level, locomotion, and object play. (The fourth activity level was not examined because these variables summed to 100%.) The amounts of asleep, sedentary activity, and vocalization did not differ among the groups (see Table 7). Moderate activity differed among the groups because the KC infants had more at 2 months and had a significant time × intervention interaction because KC infants showed a slower increase over time. (ATVV infants showed a more rapid increase over time, but this was not significant.) The amount of locomotion differed significantly between the groups with ATVV infants showing less and KC infants more than control infants. An interaction between group and age occurred because the rate of increase was faster for the ATVV infants and slower for the KC infants. Play with objects differed among the groups and showed a time × intervention interaction because KC infants displayed more initially and had a slower increase with age than the control infants.

We also examined the behaviors that made up child social: child express positive affect and gesture. Positive affect had an intervention effect, but neither intervention group differed from the control group because the two interventions had opposite effects and probably differed from each other. This variable also had a time × intervention interaction because the KC infants showed a slower increase over age than the control group. Gesture had an intervention effect, but neither intervention group differed significantly from the control group. This variable also had a time × intervention interaction because ATVV infants increased more rapidly over age.

All of the child variables except vocalization showed significant changes over time: asleep decreased, and the rest increased with age. Site only affected moderate activity because the NC-B infants exhibited more than did the infants from the other hospitals. Infants of first-time mothers showed more positive affect than later born infants.

## 4. Discussion

This study examined the effects of ATVV and KC on maternal distress and the mother–infant relationship compared to an attention control group. The infants had the expected immediate responses to the interventions as shown by differences in arousal: ATVV awakened infants (White-Traut et al., 1999, 2002a,b,c) and KC promoted sleep (Ludington, 1990). Over the first year, these interventions affected infant interactive behaviors, and KC increased the rate of decline in maternal worry, but neither intervention affected maternal distress. When mother reported her usage of the interventions, massaging the infant (including ATVV) was related to a more rapid decline in depressive symptoms than in mothers not in engaging in any intervention. Parenting stress was lower for mothers who engaged in an intervention than those who did not, and HOME

**Table 6**
Comparison of the three intervention groups on mother–infant interactive dimensions at 2 and 6 months corrected age.

| Parameter | Positive involvement | | Developmental Stim. | | HOME total | |
|---|---|---|---|---|---|---|
| | Estimate (SE) | $t$ (140)[a] | Estimate (SE) | $t$ (128)[a] | Estimate (SE) | $t$ (122)[a] |
| Intercept | 2.21 (1.21) | 1.83 | −0.25 (0.41) | −0.61 | 33.36 (1.23) | 27.20*** |
| Intervention | *F*(2, 140) = 1.36 | | *F(2, 128) = 0.13* | | *F(2, 122) = 1.36* | |
| ATVV | −2.17 (1.78) | −1.22 | −0.22 (0.59) | 0.07 | −2.66 (1.75) | −1.52 |
| Kangaroo | −2.37 (1.53) | −1.54 | −0.24 (0.57) | −0.37 | −1.97 (1.60) | −1.23 |
| Time | −0.07 (0.03) | −2.21* | 0.01 (0.01) | 1.37 | 0.08 (0.03) | 2.85*** |
| Time × Interv. | *F*(2, 140) = 1.98 | | *F(2, 140) = 0.28* | | *F(2, 122) = 1.61* | |
| Time × ATVV | −0.08 (0.05) | 1.59 | 0.09 (0.05) | 1.81 | 0.08 (0.05) | 1.69# |
| Time × KC[b] | 0.08 (0.04) | 1.79 | 0.01 (0.01) | 0.59 | 0.06 (0.04) | 1.27 |
| Site[d] | *F*(3, 140) = 3.84* | | *F(3, 140) = 7.92**** | | *F(3, 122) = 14.30**** | |
| Parity | 1.57 (0.56) | 2.80** | 0.73 (0.22) | 3.24** | 2.69 (0.68) | 3.95*** |
| | Infant social behaviors | | Infant Develop. maturity | | Infant irritability | |
| | Estimate (SE) | $t$ (135)[a] | Estimate (SE) | $t$ (128)[a] | Estimate (SE) | $t$ (135)[a] |
| Intercepta | −2.14 (0.40) | −5.33*** | −3.82 (0.48) | −7.92*** | 0.82 (0.51) | 1.62 |
| Intervention | *F(2, 135) = 3.33** | | *F(2, 128) = 5.79*** | | *F(2, 135) = 0.05* | |
| ATVVb | −0.85 (0.65) | −1.31 | −1.02 (0.76) | −1.34 | 0.04 (0.83) | 0.05 |
| Kangaroob | 0.76 (0.54) | 1.40 | 1.43 (0.65) | 2.20* | −0.18 (0.68) | −0.26 |
| Time | 0.07 (0.01) | 6.29*** | 0.11 (0.01) | 8.17*** | −0.02 (0.01) | 1.67** |
| Time × Interv. | *F*(2,135) = 6.16** | | *F*(2,128) = 9.10*** | | *F*(2,135) = 0.01 | |
| Time × ATVV | 0.02 (0.02) | 1.12 | 0.04 (0.02) | 1.90# | −0.001 (0.02) | −0.04 |
| Time × KC | −0.04 (0.02) | −2.45* | −0.05 (0.02) | −2.61* | 0.002 (0.02) | 0.09 |
| Parity | | | 0.49 (0.25) | 0.49 (0.25) | | |

*Note*: ATVV = auditory, tactile, visual, and vestibular intervention; KC = kangaroo care; Interv. = intervention; Stim. = stimulation; Develop. = developmental.

[a] Intercept df are 171 for positive involvement, 169 for developmental stimulation, 167 for HOME total, 181 df for child social and child irritability, and 169 df for developmental maturity.

# $p < 0.10$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

scores were higher for mothers who performed massage alone or along with KC. These findings suggest that choosing to perform an intervention may be as (or more) effective in improving maternal distress and the home environment as being assigned to an intervention. This effect may have been stronger for massage because this intervention was not supported by the hospitals so mothers had to seek out information. The opposite is also possible: mothers with lower distress may have been more likely to seek ways to help their infants.

Despite the lack of effect on infant responsiveness during hospitalization, both interventions affected infant interactive behaviors at 2 and 6 months. KC infants exhibited more social behaviors (though non-significant), a slower increase in social behaviors with age, and more mature behaviors but a slower increase over age than infants in the other two groups. These findings appeared to be due to KC infants having more moderate activity, more locomotion, more independent play with objects, and expressing more positive affect (though this was not significant) and a slower increase over age in each behavior. ATVV infants showed less locomotion but a faster increase over age in this behavior and in gesturing. Thus, the three groups of infants were more similar at 6 months than they were at 2 months, suggesting that the effects of these interventions decreased over time.

For both interventions, the greatest effect was on infant interactive behaviors at 2 months. By 6 months, the groups were more similar on these behaviors. However, why infant behaviors, but not maternal behaviors, were affected is unclear. The interventions have been found to have benefits for infants including increased alertness before and after feedings, better weight gain, more responsiveness during mother–infant interactions, and earlier hospital discharge for ATVV (Nelson et al., 2001; White-Traut et al., 1999, 2009, 2013; White-Traut & Tubeszewski, 1986) and more sleep, less crying, greater respiratory regularity, and better head growth for KC (Ahn et al., 2010; Chwo et al., 2002; Neu et al., 2013). The primary effects of the interventions may have been on the infant, but subtle or non-measured aspects of mothers may have also been affected.

KC had the largest number of positive effects on the infant, but the only maternal effect was that mothers worried less about their infants. Thus, we did not find the large number of positive effects of KC on mothers that have been reported in other studies (de Alencar et al., 2009; Feldman et al., 2002, 2003; Tallandini & Scalembra, 2006), possibly because the mothers in those studies were not randomly assigned but rather chose to provide KC. Similarly, we found that mothers reporting that they performed KC, regardless of assigned group, had less parenting stress. This study and several other experimental studies (Ahn et al., 2010; Roberts et al., 2000) found that mothers assigned to KC did not differ on distress from control mothers. Thus, the results of observational studies of KC appear to differ from those of randomized controlled trials.

**Table 7**
Comparison of the three intervention groups on standardized infant behaviors at 2 and 6 months corrected age.

| Parameter | Asleep | | Sedentary activity | | Moderate activity | |
|---|---|---|---|---|---|---|
| | Estimate (SE) | $t$ (148)[a] | Estimate (SE) | $t$ (148)[a] | Estimate (SE) | $t$ (135)[a] |
| Intercept | 0.72 (0.24) | 2.97** | −0.27 (0.26) | −1.05 | −1.02 (0.26) | −3.89*** |
| Intervention | *F(2, 148) = 0.99* | | *F(2, 148) = 2.56*# | | *F(2, 135) = 5.28*** | |
| ATVV | −0.09 (0.39) | −0.22 | 0.23 (0.42) | 0.55 | −0.51 (0.40) | −1.26 |
| Kangaroo | 0.38 (0.33) | 1.14 | −0.59 (0.35) | −1.71# | 0.68 (0.33) | 2.06* |
| Time | −0.26 (0.01) | −3.73*** | 0.01 (0.01) | 1.69 | 0.03 (0.01) | 4.62*** |
| Time × Interv. | *F(2, 148) = 0.07* | | *F(2, 148) = 1.42* | | *F(2, 135) = 8.80*** | |
| Time × ATVV | 0.003 (0.01) | 0.31 | −0.01 (0.01) | −0.91 | 0.02 (0.01) | 1.90# |
| Time × KC | −0.0004 (0.01) | −0.05 | 0.01 (0.01) | 0.84 | −0.02 (0.01) | −2.40* |
| Site | | | | | *F(3, 135) = 2.77** | |

| | Locomotion | | Vocalization | | Play with objects | |
|---|---|---|---|---|---|---|
| | Estimate (SE) | $t$ (135)[a] | Estimate (SE) | $t$ (135)[a] | Estimate (SE) | $t$ (135)[a] |
| Intercept | −1.17 (0.24) | −4.82*** | −0.30 (0.24) | −1.27 | −2.19 (0.44) | −11.29*** |
| Intervention | *F(2, 135) = 13.04*** | | *F(2, 135) = 0.59* | | *F(2, 135) = 3.71** | |
| ATVV | −0.95 (0.39 | −2.40* | −0.09 (0.39) | −0.23 | −0.16 (0.31) | 0.52 |
| Kangaroo | 0.93 (0.32) | 2.88** | 0.28 (0.33) | 0.84 | 0.69 (0.26) | 2.62** |
| Time | 0.03 (0.01) | 4.79*** | 0.01 (0.01) | 1.21 | 0.07 (0.01) | 12.56*** |
| Time × Interv. | *F(2, 135) = 18.84*** | | *F(2, 135) = 1.39* | | *F(2, 135) = 6.34*** | |
| Time × ATVV | 0.04 (0.01) | 3.14** | 0.01 (0.01) | 0.59 | −0.01 (0.01) | −0.65 |
| Time × KC | −0.03 (0.01) | −3.18** | −0.01 (0.01) | −1.13 | −0.03 (0.01) | −3.41** |

| | Child positive affect | | Child gesture | |
|---|---|---|---|---|
| | Estimate (SE) | $t$ (128)[a] | Estimate (SE) | $t$ (135)[a] |
| Intercept | −1.38 (0.24) | −5.72*** | −0.82 (0.25) | −3.29** |
| Intervention | *F(2, 128) = 3.77** | | *F(2, 135) = 1.41*** | |
| ATVV | −0.51 (0.38) | −1.33 | −0.44 (0.40) | −1.10 |
| Kangaroo | 0.49 (0.32) | 1.53 | 0.21 (0.34) | 0.63 |
| Time | 0.04 (0.01) | 6.19*** | 0.03 (0.01) | 3.97*** |
| Time × Interv. | *F(2, 128) = 5.58*** | | *F(2, 135) = 2.68*# | |
| Time × ATVV | 0.01 (0.01) | 1.09 | 0.23 (0.07) | 3.19** |
| Time × KC | −0.02 (0.01) | −2.31* | 0.01 (0.01) | 0.92 |
| Parity | 0.27 (0.12) | 2.36* | | |

*Note*: Variables are standardized using *Z*-scores. ATVV = auditory. tactile, visual, and vestibular intervention; KC = kangaroo care; Interv. = intervention.
# $p < 0.10$.
[a] df for the intercept *t*-test were 181 for asleep, sedentary activity, child gesture, locomotion, play with objects, and vocalization; 178 for moderate activity; and 172 for child positive.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

The ATVV intervention had fewer effects. In the primary analyses, ATVV was related to less infant locomotion and a faster increase over age in this behavior and in infant gesturing. Mothers administering this intervention did not differ from the control group on any variable. However, in analyses examining usage reported by mothers, mothers who performed massage had a more rapid decline in depressive symptoms, less parenting stress, and higher HOME scores. Thus, our study was like others in not finding many long-term effects of the short-term ATVV intervention (Nelson et al., 2001; White-Traut et al., 1990; White-Traut, & Tubezewski, 1986). However, we did find mothers who reported massaging their infant (regardless of group assignment) had less distress and provided more positive home environments than other mothers.

In addition to the interventions, two other factors – parity and recruitment site – were related to study outcomes. First-time mothers have often been found to be more responsive to their infants than mothers of later born infants (Holditch Davis & Thoman, 1988; Ravn, Smith, Lindemann, et al., 2011). Thus, it is not surprising that the maternal interactive dimensions and the total HOME score were higher for first time mothers. The primary effect of parity was on maternal behaviors as no psychological distress variable or perception of the child and only one infant interactive dimension and one infant behavior differed between first-time mothers and mothers of later born infants. The exceptions were infant developmental maturity, which was higher for the infants of first-time mothers, and child express positive affect. The better developmental maturity was probably due first-time mothers showing more talking, teaching, and positive behaviors than mothers of later-born infants because these behaviors promote infant development (Cusson, 2003; Holditch-Davis et al., 2000b; Olsen et al., 1992; Smith, Landry, & Swank, 2000). The greater amount of positive behaviors was probably due to the mother's higher involvement since infant social behaviors are closely related to maternal interactions (Holditch-Davis et al., 2007).

Recruitment site also was related to study outcomes. The mothers from Illinois averaged lower amounts of post-traumatic stress, worry, maternal interactive behaviors, and HOME scores than mothers from North Carolina. North Carolina infants

were more responsive at the time of hospital discharge. These differences were most likely due to the characteristics of mothers and infants from each hospital: infants from the North Carolina hospitals were sicker but at less psychosocial risk than the infants from the Chicago hospitals. Mothers of more seriously ill preterm infants have often been found to provide more positive interactions than mothers of healthier preterms (Holditch-Davis et al., 2003; McGrath, Sullivan, & Seifer, 1998); whereas psychosocial risk is associated with less positive and stimulating parenting (Bradley et al., 1994; Holditch-Davis et al., 2007). Differences in the research staff at each hospital might have also affected the differences. The lower attrition rate for families from hospital NC-B, for example, might be due to population differences but also might have occurred because it was the hospital nearest geographically to the study's principal investigator. These site effects did not confound the effects of the interventions because the randomization was stratified by site, and preliminary analyses indicated that the interventions did not show differential effects by site. Thus, the site differences reflect the reality of a relatively large and heterogeneous population of preterm infants in the US, rather than a source of bias. It is possible the interventions might have had a stronger effect if only conducted in one location, but the results would not be as widely generalizable.

The sample size may also limit the generalizability of this study. About 21% of the sample left the study before its end. Comparison of dyads withdrawing from the study with those completing it found that younger, single mothers and those with boys were more likely to withdraw. However, psychosocial risk cannot be the major cause of withdrawals because other variables related to psychosocial risk (e.g., race and public assistance) did not differ between withdrawals and completers. Interestingly, no infant health variable differed based on attrition despite the fact that about 20% of attrition was due to infant death. Overall, the mothers leaving the study appeared to do so from reasons that were as heterogeneous as the sample.

The variables that most clearly differed between mothers completing and leaving the study were the maternal enrollment distress measures of anxiety and depressive symptoms. Mothers who withdrew from the study averaged higher scores. Thus, maternal distress appeared to be both an outcome of the intervention and for some mothers a factor affecting their ability to engage with the intervention. However, this effect was relatively small, and a number of mothers with high distress did complete the study. Thus, instead of high distress being a risk factor, lower distress scores may have been protective against withdrawal by allowing mothers to be more fully engaged with the project.

In addition, some measures had large amount of missing values. For example, only about 60% of mothers completed the visit diary. Infants often experienced medical crises or rapid transfers to other hospitals. As a result, mothers may have been too preoccupied to complete forms, and completed forms were sometimes lost in the chaotic NICU environment. The enrollment characteristics of mothers completing visit diaries and those not completing them had only minimal differences suggesting that the data on intervention usage should generalize to the entire sample. Despite a small sample, the maternal reported usage analyses found several significant differences between the groups that were not found in the primary analyses.

In the infant responsiveness in the hospital analyses, the sample of about 65 subjects per group may have lacked power for detecting statistically significant differences. However, this sample size was similar to other studies finding short-term effects of these interventions (Rojas et al., 2003; Vickers, Ohlsson, Lacy, & Horsley, 2004; White-Traut et al., 1999, 2002a,b,c). It is more likely that interventions were less powerful when provided by mothers, rather than professional interveners, because the mothers provided the intervention less frequently than expected, as has been found with mothers of healthy infants during the postpartum hospitalization (Anderson et al., 2003). The interventions are currently being used clinically primarily by family members.

Because of a limited sample size, we could not examine all of the factors potentially affecting maternal distress and parenting. For example, several studies have suggested mothers of multiple birth infants have more distress and less positive interactions than mothers of singletons (Holditch-Davis et al., 2007; Spinelli, Poehlmann, & Bolt, 2013). Thus, determining if the interventions had differential effects on mothers of multiples and mothers of singletons would be interesting. Future research needs to be designed so that sub-groups benefitting most from the intervention can be identified.

Finally, the results of this study are limited by the evidence of diffusion of the intervention: 20–30% of KC and ATVV mothers and 58% of control mothers engaged in a non-assigned intervention. This diffusion is inevitable in translational research on interventions already in use in practice. The visit diary results showed that very few mothers engaged in a non-assigned intervention frequently, and doing a non-assigned intervention was a greater problem in the attention control group than in the intervention groups. Because intervention diffusion would have made the control group more like one of the intervention groups, our analyses were conservative tests of the effects of the interventions.

## 5. Conclusions

In conclusion, the findings of this study have implications for the care of preterm infants. We found that two frequently used NICU interventions – ATVV and KC – had positive effects on maternal psychological distress and interactions. Although the long-term effects are not as great as previously reported, the positive short-term outcomes support the continued use of these two interventions. Most likely, the small preterm infants in this study need other interventions to continue over the first year of life after ATVV or KC was discontinued. We also found some infant interactive variables (social behaviors, moderate activity, express positive affect, gesture) differed significantly among the groups, but neither the KC or ATVV group differed from the control group because the interventions had opposite effects with one intervention group higher and other lower than the control group. Thus, whether these interventions can be effectively combined is unclear and requires further study. Finally, we found more differences when mothers reported on their activities than in the primary intent-to-treat

analyses despite a smaller sample size. This suggests that encouraging mothers to perform an intervention that appeals to them may be more effective in improving infant outcomes than assigning mothers to specific interventions.

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