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Comparison of Skin-to-Skin (Kangaroo) and Traditional Care: Parenting Outcomes and Preterm Infant Development

Ruth Feldman, PhD*; Arthur I. Eidelman, MD†; Lea Sirota, MD§; and Aron Weller, PhD*

ABSTRACT. *Objective.* To examine whether the kangaroo care (KC) intervention in premature infants affects parent–child interactions and infant development.

Methods. Seventy-three preterm infants who received KC in the neonatal intensive care unit were matched with 73 control infants who received standard incubator care for birth weight, gestational age (GA), medical severity, and demographics. At 37 weeks' GA, mother–infant interaction, maternal depression, and mother perceptions were examined. At 3 months' corrected age, infant temperament, maternal and paternal sensitivity, and the home environment (with the Home Observation for Measurement of the Environment [HOME]) were observed. At 6 months' corrected age, cognitive development was measured with the Bayley-II and mother–infant interaction was filmed. Seven clusters of outcomes were examined at 3 time periods: at 37 weeks' GA, mother–infant interaction and maternal perceptions; at 3-month, HOME mothers, HOME fathers, and infant temperament; at 6 months, cognitive development and mother–infant interaction

Results. After KC, interactions were more positive at 37 weeks' GA: mothers showed more positive affect, touch, and adaptation to infant cues, and infants showed more alertness and less gaze aversion. Mothers reported less depression and perceived infants as less abnormal. At 3 months, mothers and fathers of KC infants were more sensitive and provided a better home environment. At 6 months, KC mothers were more sensitive and infants scored higher on the Bayley Mental Developmental Index (KC: mean: 96.39; controls: mean: 91.81) and the Psychomotor Developmental Index (KC: mean: 85.47; controls: mean: 80.53).

Conclusions. KC had a significant positive impact on the infant's perceptual-cognitive and motor development and on the parenting process. We speculate that KC has both a direct impact on infant development by contributing to neurophysiological organization and an indirect effect by improving parental mood, perceptions, and interactive behavior. *Pediatrics* 2002;110:16–26; *Kangaroo Care, parent–infant interaction, maternal depression, fathers, Bayley, infant development.*

ABBREVIATIONS. KC, kangaroo care; SD, standard deviation; GA, gestational age; NICU, neonatal intensive care unit; CRIB, Clinical Risk Index for Babies; BDI, Beck Depression Index; NPI,

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Neonate Parental Inventory; HOME, Home Observation for Measurement of the Environment; ICQ, Infant Characteristic Questionnaire; MDI, Mental Developmental Index; PDI, Psychomotor Developmental Index; MANOVA, multivariate analysis of variance.

Although recent research has documented the beneficial effects of mother–infant skin-to-skin contact (kangaroo care [KC]) on the physiology and behavior of premature infants, few data exist on the long-term effects of KC on infant development or on the parenting process. Since the KC method was first introduced, skin-to-skin contact has been reported to improve infant state organization, thermal regulation, respiratory patterns, and oxygen saturation; reduce apnea and bradycardia; increase rate of infant weight gain and maternal milk production; shorten hospital stay; and function as an analgesic during painful medical procedures.^{1–13} KC has also been shown to have a positive impact on mothers' sense of competence and on the mother–infant attachment process.^{14–16} These studies, however, were conducted immediately after KC was instituted or before discharge from the hospital, relied on anecdotal reports or on small samples of infants, and are often less than rigorous in design.¹³ Thus, the question of whether the KC method has long-term effects on infant development or on the parent–infant relationship remains unanswered.

Premature birth exposes the infant to a range of developmental risks. Premature infants often exhibit lower cognitive and motor skills that persist into later childhood.^{17–20} In addition, problems in the attention system have been noted and premature infants spend shorter periods in alert-scanning states,²¹ are less competent in focused attention,²² and exhibit immature visual habituation.²³ This disorganized attention, in turn, leads to difficulties in the mother–infant interaction and in the mother's ability to read the infant's messages, regulate arousal, and socially engage the infant.^{24,25}

Thus, apart from the risks of premature birth itself, developmental outcomes may stem from difficulties in the mother–infant relationship. Interactions between mothers and premature infants are often less than optimal in terms of lower maternal adaptation to infant signals, leading to decreased maternal touch, vocalization, and gaze.²⁶ Mothers of preterm infants have been noted to provide a less responsive and stimulating home environment as compared with mothers of full-term infants,²⁰ and the quality of the home environment has been shown, in turn, to

relate to the cognitive development of premature infants.^{27,28} In addition, mothers of premature infants often report higher levels of depression,²⁹ which is considered to be an independent risk factor for infant cognitive and social development.³⁰ Mothers often perceive their premature infants as less resembling the "ideal infant" as compared with term infants,³¹ and such perceptions are important determinants of maternal behavior that shape the quality of the mother–infant relationship. Although potential confounding factors, such as maternal marital status, substance abuse, and milk provision, have not been fully controlled in most of the aforementioned studies, taken together, they support the conclusion that the increased risk posed by premature birth to infant cognitive development may result to a degree from problems in the mother–infant relationship.³²

Various intervention programs applied in the neonatal period have been reported to promote premature infants' attention, learning, psychomotor maturation, and cognitive growth. Interventions such as sensory enrichment,³³ individualized development care,^{34,35} breathing bear,³⁶ and rhythmic beds³⁷ have been shown to have a positive impact on attentive, cognitive, and psychomotor development. More specific, tactile contact has been shown to affect premature infants' motor maturity and visual habituation.^{38,39} Skin-to-skin contact in the form of KC may similarly contribute to the premature infant's cognitive development, as the KC intervention integrates rhythmic, sensory, and tactile components into the mother–infant context. Furthermore, the contribution of KC to infant state regulation^{11,13} may promote the development of cognitive skills, in light of the findings that link state organization in the newborn period and cognitive development in later childhood.⁴⁰

In addition to its impact on the infant's attention system, physiologic maturation, and cognition, KC may contribute to the mother's perceptions and behavior. Mothers who provide KC report to have more positive feelings toward the infant and better sense of the parenting role.^{11,14} The active care of the infant and the physical bonding may reduce maternal depression and increase her familiarity with the infant and his or her interactive signals. Furthermore, the effects of KC on infant state organization may improve infant alertness during mother–child interaction, resulting in increased maternal involvement. Finally, because mothers' and fathers' interactive behavior toward their infant is correlated,⁴¹ gains in mother–infant interactions after KC may also be expressed in the father's relationship to the infant.

In light of the above, the goal of this study was to examine the effects of KC on 3 domains of early development: maternal and paternal perceptions, mother–infant and father–infant interactions, and the infant's cognitive development across the first 6 months of life. We hypothesized that after KC, mothers would be less depressed and have a more positive perception of the infant and that skin-to-skin contact would increase maternal behaviors such as gaze and touch.⁴² It was expected that KC mothers

and fathers would be more sensitive and adaptive toward their infant and would provide an environment more suitable for the child's developmental needs. Regarding gains for the infant, it was hypothesized that infants who received KC would be more alert, would have a less difficult temperament, and would show improved cognitive and psychomotor development in early infancy.

METHODS

Participants

Participants were 146 premature infants whose mean birth weight was 1270 g (standard deviation [SD]: 343.49; range: 530–1720 g) and mean gestational age was 30.65 weeks (SD: 2.76; range: 25–34 weeks). Of these, 73 infants underwent KC and 73 served as controls. Infants in the 2 groups were matched for gender, birth weight, gestational age, and medical risk. Exclusion criteria were intraventricular hemorrhage grade 3 or 4, perinatal asphyxia, or metabolic genetic disease. All families were middle-class, representing the majority of young families in the Israeli population.⁴³ Families in the 2 groups were matched for maternal and paternal age, education, parity (primiparous versus multiparous), and maternal employment (no, part-time, or full-time employment). Mothers all were married to the child's father, and in all families at least 1 parent was employed. None of the mothers reported smoking or using drugs during the pregnancy, and drug-using mothers were not included. Recent immigrants were not included because of difficulties in completing questionnaires. Twins and singletons, equally numbered in the 2 groups, were matched separately for birth weight, gestational age, and medical risk. Family demographics and infant medical information for the 2 groups are summarized in Table 1. No group differences were found in mode of delivery, Apgar scores, and the amount of maternal milk the infants received or degree of breastfeeding. The level of mothers' self-reported social support⁴⁴ was comparable in the 2 groups.

Recruitment

As KC is a standardized care option in many hospitals in Israel and was not considered an experimental technique; prospective randomization of KC and control subjects was precluded by the institutional research boards. Comparison thus was performed between matched infants cared for in 2 different hospitals, one of which provided KC care and one that did not. This method of recruitment minimized the selection bias that would have occurred if all of the infants had been from the same hospital, and the comparison was of infants whose mothers chose KC and those who did not. Likewise, as this recruitment was during a defined time period, the problem of historical controls was resolved. The nurseries in the 2 hospitals were level 3 referral centers with a comparable number of admissions, case mix, physician level and experience, and nurse–patient ratios. Infants who participated in the study (both KC and control subjects) were cared for by the same physician–nurse team that cared for infants who were not in the study. Mothers delivered in a given hospital because of the geographic catchment area where they lived, not because of any care practice. The physical environment in both nurseries, as to light and noise level, was comparable. In both units, parents had unlimited privileges and were encouraged to participate actively in infant care routines.

Consecutive mothers who delivered in the 2 hospitals and who matched the study criteria were approached in each hospital to enroll in either KC or control groups as soon as their infants became eligible. We initially enrolled 73 mother–infant control pairs from hospital A, and 53 matched pairs who received KC were recruited from hospital B. Subsequently, after KC was instituted in hospital A, an additional 20 infants from hospital A were enrolled in the KC group. The final design, therefore, was as follows: hospital A had 73 control subjects + 20 KC; hospital B had 55 KC. No differences in infant birth weight, gestational age (GA), and family demographics were found in the 2 subgroups of KC infants born in the 2 hospitals (53 infants in B and 20 infants in A).

Eight mothers who were approached to participate in the KC group declined, and 4 of those still provided KC. Six mothers who

TABLE 1. Family Demographic and Infant Medical Variables

	KC (N = 73)		Control (N = 73)	
	Mean	SD	Mean	SD
Birth weight (g)	1245.85	328.21	1289.87	358.08
GA (wk)	30.38	2.50	30.82	2.98
CRIB (medical risk score)	2.29	2.98	2.25	2.96
Mother age (y)	29.63	4.72	29.07	6.14
Mother education (y)	14.70	1.94	14.11	2.32
Father age (y)	32.29	5.89	32.46	7.75
Father education (y)	14.47	2.27	14.55	3.78
M/F ratio	37/36		38/35	
Primiparous/multiparous	36/37		36/37	
Maternal milk (full, >50%, none)	27.5%, 27.5%, 45%		26%, 31.5%, 42.5%	
Cesarean section (yes/no)	48/25		46/27	
Apgar 1	7.21	1.90	7.56	1.30
Apgar 2	8.67	1.03	8.50	1.14
Social support network	30.08	9.35	29.43	11.19

were approached to participate as control subjects declined, citing time constraints as the main reason. These mothers and infants did not differ from the participating families on any demographic or infant medical variables.

Intervention

Infants were enrolled at 31 to 33 weeks' postconception, when their medical situation stabilized and they were no longer being ventilated. KC was begun between 31 and 34 weeks' GA. Infants who were receiving supplementary oxygen by nasal catheter and/or intravenous fluids were included in the study. Infants were enrolled when the mothers agreed to perform KC for at least 14 consecutive days for at least 1 hour daily. Infants were taken out of the incubator, undressed (wearing only a diaper and sometimes a cap), and placed between the mother's breasts. During KC, infants remained attached to a cardiorespiratory monitor and were observed by the nurses, who recorded the exact time that mothers and infants remained in skin-to-skin contact. Infants' mean postnatal age at entry to the KC group was 12.45 days (SD: 11.11; range: 3–40 days) and at entry in the control group was 13.0 days (SD: 11.56; range: 2–41), with no group differences. During this period, mothers provided on average of 26.62 hours of kangaroo contact (SD: 12.14). For 5 infants in hospital B (9.4%) and 2 infants in hospital A (10%), fathers also provided sporadic KC in addition to the mother, and developmental outcomes or participation in follow-up was unrelated to paternal KC. During KC, mothers were seated in a standardized rocking chair and were provided with a bedside screen to ensure privacy. No change in nursery ambient light or sound level was performed during KC.

Infants and their mothers were observed before discharge at 37 weeks' GA and after discharge at 3 and 6 months' corrected age. Twelve infants missed the 3-month visit, for 14 additional infants the fathers were not present during the 3-month visit, and 13 infants missed the 6-month visit. These infants and families did not differ from the remaining participants on any demographic or infant variables, including group assignment. Reasons for missing follow-up visits included inability to locate parents, families moving to a far location, and time and scheduling difficulties. Reasons were comparable across groups. Assessment at 37 weeks' GA took place in the hospital, the 3-month assessment was conducted at the family's home, and the 6-month assessment was conducted at the developmental laboratory. At 37 weeks' GA, mothers and infants were videotaped in a free mother–infant interaction in a separate room at the neonatal intensive care unit (NICU) for 10 minutes. At 3 months, trained observers visited the home for approximately 1.5 hours when mother and father were present. At 6 months, infants visited the laboratory for developmental testing. At all time points, mothers completed self-report measures.

The study received the approval of the institutional research board, and all mothers provided signed informed consent.

Measures

Infant medical risk was measured by the Clinical Risk Index for Babies (CRIB).⁴⁵ Each of the following items receives a certain

score according to predetermined range: birth weight, GA, minimum and maximum fraction of inspired oxygen, minimum base excess during the first 12 hours, and the presence of congenital malformations. Scores were then summed to create the total CRIB score. Infants were grouped into high- and low-risk groups using the median split of the CRIB score.

Predischarge: 37 Weeks' GA

Mother–Infant Interaction

Ten minutes of mother–infant interaction were videotaped. Coding of all tapes was conducted at a central university laboratory by trained observers, unaware of the infant's group membership or the study's hypotheses. For each 10-second epoch, the coders marked 1 of several behaviors along 5 categories using the Mother–Newborn Coding System.⁴⁶ Categories and behaviors were as follows: Maternal Gaze, toward infant, toward stranger, ambiguous, gaze aversion; Maternal Affect, positive, negative, neutral; Maternal Talk, to infant, to stranger, sing, "mothereese"; Maternal Touch, touch, hug, cradle, and stimulate; Infant State, fuss, cry, alert-scanning, gaze aversion, and sleep. In addition, mother–infant interaction was globally rated on a 5-point scale (low to high) for Maternal Adaptation and Maternal Intrusiveness. Reliability was conducted for 15 mother–infant dyads, and mean reliability was 93%, $\kappa = 0.82$. On the basis of the above behavioral categories, the following variables were calculated: Maternal Positive Affect (the proportion of time mothers spent in positive affect), Maternal Touch (sum of the proportions of touch, hug, cradle, and stimulate), Maternal Vocalization (sum of talk, sing, and vocalize), Maternal Visual Regard (proportion of mother gaze at infant), Infant Alert and Infant Gaze Aversion (proportion of time infant spent in alert-scanning state and in gaze aversion), and the global Maternal Adaptation code.

The Beck Depression Inventory (BDI)⁴⁷ and the Neonate Parental Inventory (NPI)⁴⁸ were completed by the mother. The NPI includes two 6-item parts. The first part considers behaviors typical of the "average infant," and the second examines the same behaviors regarding "my infant." The total score is the difference between the mother's perception of the averaged infant and her child.

Three Months: Home Visit

Home Observation for the Measurement of the Environment (HOME)⁴⁹ evaluates the quality of the child's home environment and was administered at the home with both parents and child present. The HOME includes 55 items and information noted during a 1.5-hour observation period in addition to direct questions of the parents. Six composites are computed (Table 2), and a total score is calculated by summing these composites. Research assistants, unaware of infant group assignment, were trained to 95% reliability and observed and questioned the mother and the father separately. Separate scores were calculated for mothers and fathers on composites 1, 2, and 5 and on the total HOME score.

Infant Characteristic Questionnaire (ICQ),⁵⁰ a measure of infant

TABLE 2. Univariate Analysis of HOME

	KC		Control		Univariate F
	Mean	SD	Mean	SD	
HOME mothers	N = 67		N = 67		
Emotional and verbal responsiveness	16.13	2.52	14.96	2.38	6.79†
Avoidance of restriction	5.66	0.75	5.64	0.73	NS
Organization of physical environment	5.38	1.36	4.80	1.06	5.42*
Provision of appropriate play material	12.44	2.78	12.63	1.91	NS
Parental involvement with child	1.42	0.52	1.23	0.72	NS
Opportunities for variety in daily life	13.54	3.72	12.19	3.04	5.09*
Total HOME score	54.49	7.68	51.71	5.49	4.70*
HOME fathers	N = 59		N = 61		
Emotional and verbal responsiveness	14.24	3.89	12.74	3.89	3.97*
Avoidance of restriction	5.62	0.74	5.62	0.75	NS
Organization of physical environment	5.38	1.36	4.80	1.06	5.28*
Provision of appropriate play material	12.44	2.78	12.63	1.91	NS
Parental involvement with child	1.42	0.52	1.23	0.72	NS
Opportunities for variety in daily life	13.54	3.72	12.19	3.04	3.99*
Total HOME score	52.40	6.58	48.43	6.53	3.89*
Temperament					
Fussy-difficult—mothers	20.08	6.07	21.98	6.75	NS
Fussy-difficult—fathers	22.07	7.20	23.71	7.80	NS

NS indicates not significant.

* $P < .05$.

† $P < .01$.

temperament that includes 24 items rated on a 9-point scale, was completed by mothers and fathers separately, and the Fussy-Difficult factor of the ICQ was used.

Six Months: Developmental Laboratory Visit

Infant cognitive development was assessed by a trained psychologist blind to group assignment, with the Bayley Scales of Infant Development, 2nd edition (Bayley-II).⁵¹ The Bayley-II yields 2 developmental indices: Mental Development Index (MDI) and Psychomotor Developmental Index (PDI).

Mother-Infant Interaction

Five minutes of face-to-face mother-infant interactions were videotaped. Interactions were coded with the Coding Interactive Behavior.⁵² The Coding Interactive Behavior is a global rating system of parent-infant interaction. It includes 42 codes rated from 1 (low) to 5 (high). The system has been validated in several studies and showed differences in parent-infant interactions related to infant age, cultural background, and developmental risk conditions.^{41,53,54} Two factors were calculated: 1) Maternal Sensitivity based on 10 items: acknowledgment of the infant's interactive signals, elaboration of the child's vocalizations and movements, warm and positive affect, affectionate tone of voice, fluency of the interaction, consistency and predictability of style, resourcefulness in dealing with the infant's negative states, appropriate range of affect, and adaptation to the infant's state and signals (Cronbach $\alpha = 0.92$); 2) Child Social Involvement calculated from 5 items: child initiation of interactive bids, child positive affect, child vocalization, child alertness, and infant-led interactions (Cronbach $\alpha = 0.86$). Two coders, unaware of group assignment, were trained to 90% agreement. Reliability was measured on 15 mother-infant interactions and averaged 93% ($\kappa = 0.81$).

Statistical Analysis

Each of the 7 clusters of outcome measures was examined with a separate multivariate analysis of variance (MANOVA) with intervention (KC, control) and medical risk (high, low) as the between-subject factors. Univariate analysis of variance followed significant main effect findings on the MANOVA, and post hoc comparisons followed significant interaction effects. The 7 clusters of outcomes were obtained as follows: 1) mother-infant interaction (predischARGE), 2) maternal perceptions (BDI, NPI; predischARGE), 3) HOME mothers (3 months), 4) HOME fathers (3 months), 5) infant temperament (3 months), 6) infant cognitive development (MDI, PDI; 6 months), and 7) mother-infant interaction (6 months). Two hierarchical multiple regression models

were computed to predict infants' MDI and PDI scores by the 5 clusters of outcome variables across the first 6 months. The sample size provides sufficient power ($d = 0.85$) to detect a medium effect size (0.5).^{55,56}

RESULTS

PredischARGE

Mother-Infant Interaction

A MANOVA conducted for the mother-infant interaction variables showed an overall effect for KC intervention (Wilks' $F [df = 6, 137] = 12.47; P < .001$), ie, more positive interactions in the KC group. An overall effect was also found for medical risk (Wilks' $F [df = 6, 137] = 2.53; P < .05$), ie, less optimal interactions between mothers and high-risk infants. Univariate tests, as tabulated in Table 3, indicated that after KC, mothers looked more at their infants, touched the infant more frequently, showed more positive affect, and were more adaptive to the infant's signals. Infants who received KC had more alert-scanning episodes and showed less gaze aversion during mother-infant interactions. Univariate tests for medical risk showed that infants at lower risk were more alert ($F [df = 1, 137] = 2.92; P < .01$), and mothers of lower-risk infants displayed more positive affect ($F [df = 6, 137] = 4.14; P < .01$) and looked more at the child ($F [df = 1, 137] = 3.05; P < .01$) as compared with premature infants born at high risk. These findings are depicted in Fig 1.

Maternal Perceptions

A MANOVA conducted for the 2 maternal self-report measures at term (BDI, NPI) revealed an overall positive effect for KC intervention (Wilks' $F [df = 2, 141] = 9.10; P < .001$). Univariate tests showed that mothers who provided KC to their infants reported less depressive symptoms and perceived the infant as more normal and less divergent from the "average infant" (Table 3). An overall effect was also found for

TABLE 3. Univariate Analysis of Mother–Infant Interaction and Maternal Self-Report at Term Age

	KC (N = 73)		Control (N = 73)		Univariate F
	Mean	SD	Mean	SD	
Mother–infant interaction					
Maternal positive affect*	0.38	0.10	0.13	0.29	22.39§
Maternal touch*	0.45	0.23	0.26	0.14	23.38§
Maternal vocalization*	0.19	0.14	0.18	0.14	NS
Maternal visual regard*	0.45	0.22	0.31	0.10	16.21§
Maternal adaptation†	4.00	1.12	3.32	1.13	10.89§
Infant alert*	0.07	0.08	0.03	0.05	8.18§
Infant gaze aversion*	0.29	0.15	0.38	0.27	4.86‡
Maternal attitudes					
Maternal depression	6.68	5.55	9.05	4.27	5.68‡
Neonatal perception inventory	1.09	3.74	3.32	3.46	11.20§

NS indicates not significant.

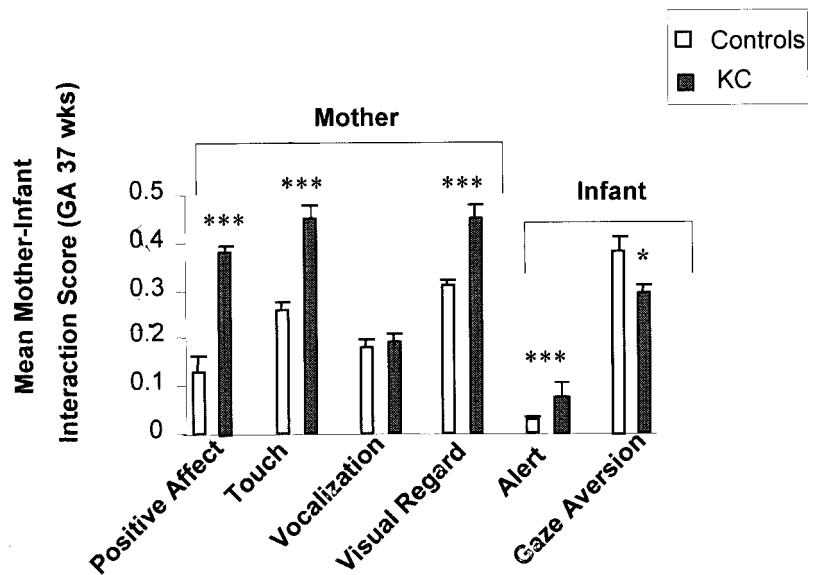
* Numbers for states represent proportion of time for each behavior.

† Numbers are coded globally on a scale of 1 to 5.

‡ $P < .05$.

§ $P < .001$.

Fig 1. Mother–infant interactive behaviors at 37 weeks' GA in KC and control subjects. * $P < .05$; *** $P < .001$.



medical risk (Wilks' $F [df = 2, 141] = 4.86; P < .01$), with univariate tests showing that mothers of high-risk premature infants had significantly higher depression scores (mean: 9.35; SD: 1.74) than mothers of low-risk preterms, (mean: 6.85; SD: 1.74). A significant interaction effect of KC intervention by medical risk was found (Wilks' $F [df = 2, 141] = 2.67; P < .05$). Post hoc comparisons (Duncan's test) revealed that among low-risk infants, differences between KC mothers (mean: 4.90; SD: 2.94) and control subjects (mean: 8.80; SD: 3.69) were highly significant ($F [df = 1, 72] = 20.92; P < .001$). In the high-risk group, the differences between KC (mean: 9.03; SD: 4.54) and control subjects (mean: 9.62; SD: 4.16) were not significant (Fig 2).

Three Months

Mothers' HOME

A MANOVA computed for the mothers' HOME variables showed an overall effect for KC intervention (Wilks' $F [df = 7, 123] = 2.99; P < .01$), indicating that KC mothers provided a better home environment.

Fathers' HOME

A similar MANOVA for the fathers' HOME variables showed a comparable positive overall effect for KC intervention (Wilks' $F [df = 7, 110] = 2.45; P < .05$), indicating that fathers also provided a more optimal environment for their infants. There was no overall effect on the mothers' or fathers' HOME scores when analyzed by medical risk. Univariate analyses, reported in Table 2, showed that both mothers and fathers of KC infants expressed higher levels of emotional and verbal responsiveness, were better adept at organization the physical and temporal environment, and were more skilled in providing opportunities for variety in daily life. Mothers' and fathers' total HOME was higher for the KC group (Fig 3).

Infant Temperament

A MANOVA computed for the mothers' and fathers' fussy-difficult temperament scores from the ICQ revealed no significant effect of KC intervention or medical risk.

Fig 2. BDI scores of mothers of KC and control premature infants born at high and low medical risk. *** $P < .001$.

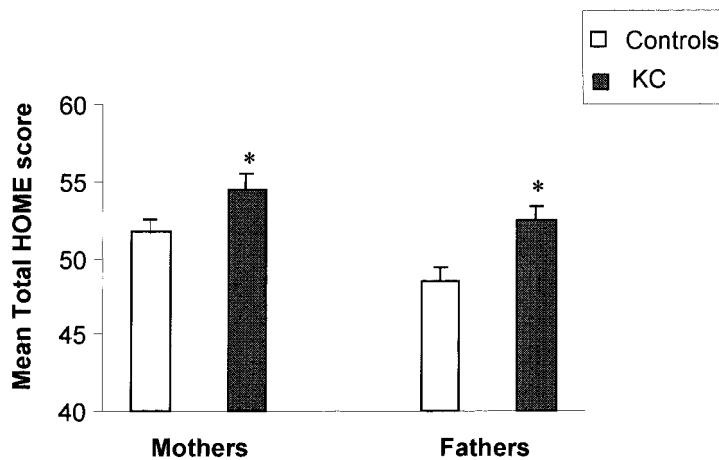
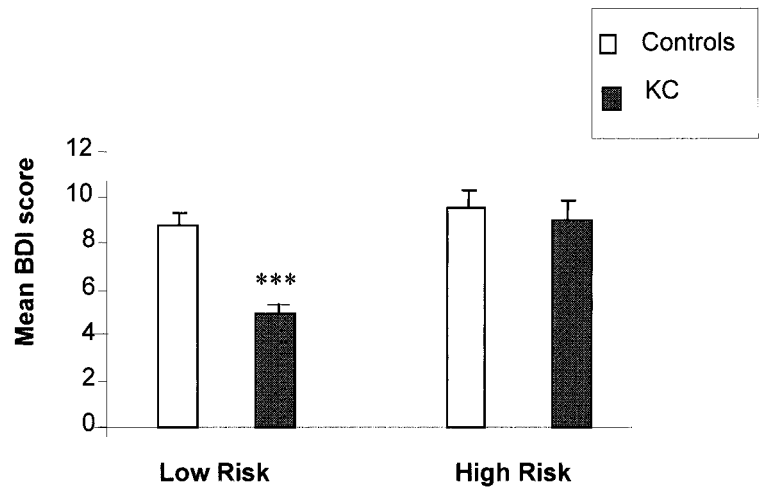


Fig 3. Mothers' and fathers' total HOME scores at 3 months' corrected age in KC and control subjects. * $P < .05$.

Six Months

Infant Cognitive Development

A MANOVA conducted for the 2 developmental indices of the Bayley-II (MDI and PDI) showed a significant overall effect for intervention (Wilks' $F [df = 2, 128] = 5.41; P < .01$), indicating improved infant development in the KC group. A separate overall effect was found for medical risk ($F [df = 2, 128] = 3.04; P < .05$), indicating that infants born at higher risk had slower development. An overall interaction effect of intervention and medical was also found ($F [df = 2, 128] = 5.41; P < .01$). Univariate

tests (Table 4) showed that after KC, infants scored higher on both the MDI and the PDI indices of the Bayley-II at 6 months' corrected age. Univariate tests for medical risk showed that infants born at lower risk scored higher on the MDI (mean: 95.34; SD: 8.30) as compared with infants born at higher risk (mean: 92.22; SD: 9.55). Post hoc comparisons (Duncan's test) revealed that among low-risk infants, differences between the PDI scores of KC infants (mean: 87.31; SD: 20.32) and control subjects (mean: 84.09; SD: 12.02) were not significant. However, among high-risk infants, differences between KC infants

TABLE 4. Univariate Analysis of Infants' Mental and Psychomotor Development and Mother-Infant Interaction at 6 Months

	KC (N = 66)		Control (N = 67)		Univariate F
	Mean	SD	Mean	SD	
Infant development					
MDI	96.39	7.23	91.81	9.80	6.55‡
PDI	85.47	18.42	80.53	13.33	4.68†
Mother-infant interaction					
Maternal sensitivity*	4.20	0.64	3.86	0.76	5.36†
Infant social involvement*	2.42	0.68	2.27	0.89	NS

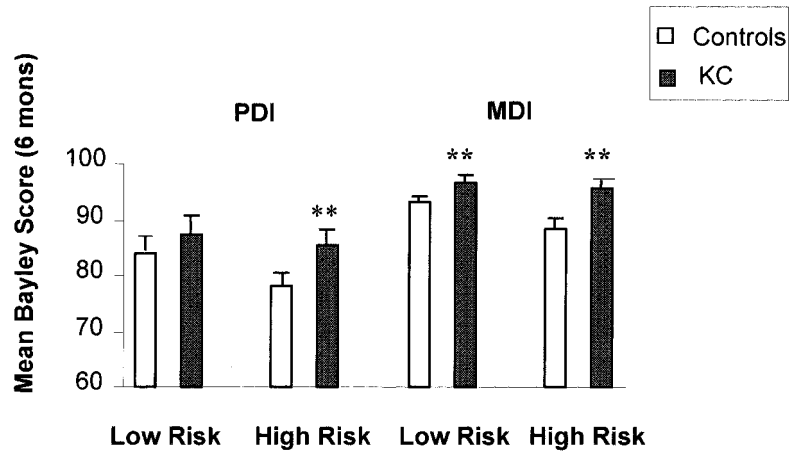
NS indicates not significant.

* Numbers are coded globally on a scale of 1 to 5.

† $P < .05$.

‡ $P < .01$.

Fig 4. MDI and PDI scores of KC and control premature infants born at high and low medical risk. ** $P < .01$.



(mean: 85.14; SD: 17.88) and control subjects (mean: 77.91, SD: 13.68) were significant ($F [1, 62] = 6.27$; $P < .01$). These findings indicate that KC has an especially positive impact on the motor development of high-risk premature infants (Fig 4).

To control for the infant's home environment in assessing cognitive development, a MANOVA with MDI, and PDI as the dependent variables, KC as the between-subject factor, and parents' HOME as a covariate was computed. Results indicated that, while controlling for mothers' HOME, the cognitive development of KC infants was significantly higher as compared with controls ($F [2, 126] = 3.34$; $P < .05$). Similar results were found for the KC group while controlling for the fathers' HOME ($F [2, 114] = 3.02$; $P < .05$).

Mother-Infant Interaction

A MANOVA conducted for the 2 mother-infant interaction factors—maternal sensitivity and child social involvement—revealed an overall effect for the KC intervention (Wilks' $F [df = 2, 128] = 4.21$; $P < .05$), suggesting that mother-infant interactions were more optimal in the KC group. The medical risk status of the infant did not effect these interaction scores. Univariate tests (Table 4) indicated that maternal sensitivity was higher at 6 months among

mothers who provided KC in the neonatal period (Fig 5).

Prediction of Infants' Mental and Psychomotor Development at 6 Months

For examining the hypothesis that maternal, paternal, and infant variables each contribute to the infant's cognitive development, 2 hierarchical regression models were computed to predict infants' mental and psychomotor development at 6 months by the parents' perceptions and behaviors in the first half-year. Predictors were entered in 7 hierarchical blocks in a predetermined order. In the first block, infant medical risk was entered as a covariate, to partial out variance related to the infant's biological risk. In blocks 2 to 4, neonatal measures were entered (maternal interactive behavior, infant interactive behavior, maternal perceptions). In the fifth block, the 3-month measures were entered (mothers' and fathers' total HOME scores). In the sixth block, mother-infant interaction factors were entered (maternal sensitivity, infant social involvement). Finally, KC was entered as a binary variable to examine whether the provision of skin-to-skin contact contributed to infants' mental and psychomotor development above and beyond all other variables in the model.

Results of the 2 regression models are presented in

Fig 5. Mother-infant interaction at 6 months' corrected age in KC and control subjects. * $P < .05$.

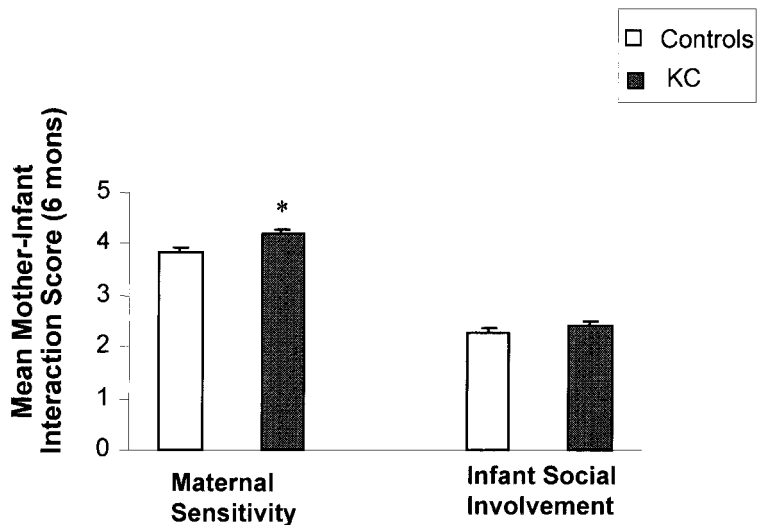


Table 5. Infants' MDI was independently predicted by medical risk at birth, by infant alertness during mother–infant interaction at 37 weeks' GA, by lower maternal depression, and by higher maternal sensitivity and infant social involvement at 6 months. KC had an independent contribution to the prediction of infants' mental development of 5% above and beyond all other variables in the model. In combination, all of the predictor variables including KC explained 27% of the variability in infants' mental development.

Infants' PDI was predicted by mothers' behavior during mother–infant interaction at 37 weeks' GA, in particular the amount of maternal touch, by decreased maternal depression, and by the mother's total HOME score at 3 months. Again, KC had a unique contribution to the prediction of infants' PDI scores of 4% above and beyond all other variables in the model. In combination, all of the predictor variables including KC explained 26% of the variability in infants' psychomotor development.

DISCUSSION

Results of this study, among the first to demonstrate long-term impact of the KC intervention method, indicate that KC had a positive contribution to 3 dimensions of early development: maternal and paternal perceptions, maternal and paternal behavior, and infant development, independent of the infant's medical status. Mothers who provided KC were less depressed, perceived their infants as less abnormal, and provided increased maternal affiliative behaviors during the hospitalization period. Parents from the KC group provided a more sensitive and appropriately stimulating home environment, and KC mothers were more sensitive, adaptive, warm, and resourceful during social interactions at 6 months. Infants who had received KC were more socially alert, and their Bayley developmental scores at 6 months were higher in the mental (MDI) and motor (PDI) domains. Thus, these findings indicate that KC had a positive impact on both the child's early development and the development of mothering and fathering across the first 6 months of life. The

gains in infants' mental skills were independently related to parental perceptions, maternal and paternal behaviors, and infant attention. These findings are in line with previous research that pointed to the joint contribution of maternal behavior and infant attention to cognitive development,³² independent of the neonatal medical status.

Several theoretical models may provide a framework for understanding these findings. The first relates to the effects of maternal proximity and separation in the immediate postbirth period on infants' physiologic homeostasis, attention, and exploration. Hofer's work⁵⁷ in animals delineated the complex relations between various aspects of maternal proximity, ie, maternal touch, smell, body heat, and nursing, on arousal regulation and attention. In premature human infants, interventions that provide separate components of the "maternal proximity" complex, such as rhythmic stimulation or sensory enrichment, have been shown to affect infants' cognitive skills.^{33,37} Maternal–infant skin-to-skin contact provides maternal proximity during a period when maternal separation is common and functions to increase infant attention, alertness, and exploratory skills, leading ultimately to better infant mental and motor skills.

The second perspective considers the effects of early mother–infant separation on maternal behavior in addition to its impact on the infant. The psychological system implicated in the process of attachment has been associated with oxytocin, a hormone released during parturition and nursing as well as during contact, touch, and fondling.⁴² Oxytocin has been shown to play a role in the initiation of maternal affiliative behavior and to affect positively the mother's mood.⁵⁸ Skin-to-skin contact is considered to function as an oxytocin-releasing agent and has been shown to increase maternal milk volume.⁴ It is possible that the increase in maternal affiliative behavior (eg, touch, gaze, positive affective display) and the decrease in depression are related to these underlying biological processes as well as to the psychological process of maternal attachment. Furthermore, the improvement in maternal affiliative

TABLE 5. Predicting Infants' Mental and Psychomotor Development at 6 Months

Predictors	MDI					PDI					
	β	MR	R ² Change	Adj R ²	F Change	β	MR	R ² Change	Adj R ²	F Change	df
Medical risk	-0.25*	0.23	0.05	0.04	6.57*	-0.19	0.11	0.01	0.00	1.40	1, 113
Maternal touch	0.22*					0.39*					
Maternal vocalization	0.03					0.21					
Maternal visual regard	0.02					0.05					
Maternal adaptation	0.14	0.28	0.02	0.05	0.88	0.10	0.30	0.08	0.06	3.06*	5, 109
Infant alert	0.27*	0.34	0.04	0.07	4.60*	0.10	0.32	0.01	0.06	1.16	6, 108
Maternal depression	-0.19*					-0.28†					
NPI	0.03	0.39	0.04	0.09	3.17*	-0.15	0.42	0.08	0.12	4.12*	8, 106
HOME total mothers	0.17					0.24*					
HOME total fathers	0.15	0.40	0.01	0.09	0.61	0.17	0.46	0.04	0.14	2.97*	10, 104
Maternal sensitivity	0.21*					0.12					
Infant social involvement	0.18*	0.46	0.06	0.13	6.04†	0.09	0.47	0.01	0.14	0.94	12, 102
KC	0.26*	0.50	0.05	0.16	5.19*	0.25*	0.50	0.04	0.17	4.72*	14, 100
	R ² Total = 0.27, F(14, 100) = 3.06; P < .01					R ² Total = 0.26, F (14,100) = 2.96; P < .01					

* P < .05.

† P < .01.

behavior in the neonatal period seems to persist across the first months of life, and at 6 months mothers who provided KC were more sensitive, warm, and adaptive.

The third perspective is provided by the transactional model of early development.⁵⁹ According to this view, maternal and infant behaviors affect each other in an ongoing, mutually influencing manner to shape developmental outcomes. Infants who are more alert as newborns may elicit more sensitive mothering, leading to further improvement in the maternal style and to better developmental outcomes. Similarly, increase in maternal adaptation in the neonatal period may promote infant social attention and outcomes. The separate effects of KC on mother and infant continue to influence the mother-child relationship, have an impact on the father-child relations, and create a better environment for development. Previous studies assessing intervention outcomes and cognitive development in low-birth-weight premature infants have confirmed the separate and cumulative effects of biological and social risk on development,⁶⁰⁻⁶² emphasizing the need to address both infant liabilities and maternal difficulties in devising intervention programs.

The home environment of the KC infants was found to be more optimal in terms of maternal and paternal sensitivity, parental organization of the environment, and the availability of variety in the infant's daily life. Because families in the 2 groups came from similar socioeconomic backgrounds, with comparable levels of education, income, and social support networks, we view these differences as resulting from the KC intervention, which contributed to the parents' responsiveness to the needs of their premature infant. Moreover, KC was still found to have a positive impact on infants' cognitive development while controlling for both maternal and paternal HOME scores, indicating that the relations between the KC intervention and infant cognitive development were independent of the home environment.

KC had a significantly more positive impact on the motor development of high-risk as compared with low-risk preterm infants. These findings may be interpreted in line of the evolutionary perspectives on "differential susceptibilities to rearing environment."⁶³ This perspective suggests that infants who are born at higher risk are more dependent on corrective environmental inputs, as their preparedness to extract necessary experiences for development from their environment is limited. We suggest that high-risk infants may be less skilled in eliciting maternal touch as a result of factors such as incoherent signals or higher levels of withdrawal behavior during mother-infant interaction.⁶⁴ Therefore, structured intervention involving maternal contact, such as KC, may be particularly beneficial to the development of motor skills in high-risk infants, especially because touch therapy has been shown to improve motor maturity in preterm infants.³⁹

Although there is no doubt that the severity of the medical condition in preterm infants is a factor in the

infant's ultimate development, it is important to emphasize that our findings were independent of medical risk, as infants in the 2 groups were matched for medical risk and risk was statistically controlled in the regression analyses. Previous studies have noted that mothers look less and display less positive affect toward high-risk infants, while such infants are less alert,^{24,26} and these maternal and infant behaviors are possibly mutually distracting. Mothers of high-risk infants are also more depressed, a process that potentially minimizes positive interactions and bonding with the infant. Thus, interventions in the NICUs should be aimed at increasing emotional investment in the parenting process among mothers of very sick preterm infants, and our results suggest that KC is a successful intervention for achieving this goal.

Results of the 2 regression models point to the different predictors of infants' attentive-perceptual (MDI) and perceptual-motor (PDI) competencies at 6 months. Infants' mental score was predicted by infant alertness during social interaction with the mother in the neonatal period, pointing to the relationship between infant attention and ultimate cognitive skills. Infants whose mothers were less depressed also showed better cognitive abilities, findings consistent with previous research regarding the detrimental impact of maternal depression on children's cognition.³⁰ Furthermore, infants whose mothers were more sensitive and were more socially active at 6 months had higher MDI scores, pointing to the ongoing relations at various developmental periods between maternal and child social behavior and infant developmental outcomes. Psychomotor development (PDI), however, was predicted by maternal touch during social interaction in the neonatal period and by the nature of the home environment. These results indicate that early maternal touch had an impact on psychomotor skills 6 months later. Such findings extend previous reports on the concurrent relations between massage therapy and motor maturity during the neonatal period.^{38,39} Similarly, the findings indicate that an organized, enriched, and sensitive home environment—as measured by the HOME—had a unique contribution to the premature infant's psychomotor development.

The limitations of the study relate primarily to the fact that this was not a prospective randomized study of KC and control infants. As noted, KC is not an experimental technique in Israel but is considered to be a standard care option, and thus randomization was precluded by the institutional research boards. That different hospitals introduced the KC methods at different points in time provided an opportunity to compare from 2 hospitals matched mother-infant dyads who were being treated by otherwise similar clinical protocols. Thus, the selection bias that would have ensued from comparing infants from mothers who chose KC as opposed to those who refused to provide kangaroo contact was avoided. Future research is clearly needed to examine whether the gains secondary to KC noted in the first half-year persist into later infancy and childhood. We also need to know whether the provision of KC by people

other than the mother, such as fathers, grandparents, personnel, or volunteers, has similar effects on the development of premature infants. Finally, comparison of outcomes with other intervention methods, such as massage therapy, minimal handling, or enriched environments, is required to determine which method or combination thereof best fits a specific patient population to provide the most optimal intervention for the high-risk premature infant and his or her parents.

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THE CHINESE ARE COMING! THE CHINESE ARE COMING!

“... The [*New York Times*] Education Life supplement just reported that the best-selling book in China for the past 16 months is a book, in Chinese, about how to get your teenager into Harvard, titled ‘Harvard Girl Yiting Liu.’ In this book, a Chinese mother shares her ‘scientifically proven methods’ for getting her daughter into Harvard. It has sold more than 1.1 million copies and triggered 15 copycats for how to get into Columbia, Oxford, or Cambridge. In the same week it was reported that the normally intelligent Saudi ambassador in London, Ghazi Algosaiibi, had published a poem in *Al-Hayat* in praise of the 18-year-old Palestinian girl who blew herself up in an Israeli supermarket, saying to her, ‘You died to honor God’s word’... A society that makes a best-seller about how to get its teenagers into Harvard will eventually build Harvards of its own. But leaders who glorify a teenager who committed suicide in a supermarket full of civilians will never build a country.”

Friedman TL. *New York Times*. April 24, 2002

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Comparison of Skin-to-Skin (Kangaroo) and Traditional Care: Parenting Outcomes and Preterm Infant Development

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