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The Effects of Kangaroo Care on the Neurodevelopment of Preterm Infants in the Neonatal Intensive Care Unit (NICU)

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THE EFFECTS OF KANGAROO CARE ON THE NEURODEVELOPMENT OF
PRETERM INFANTS IN THE NEONATAL INTENSIVE CARE UNIT (NICU)

by

TIFFANY SARG

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
in the College of Nursing
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at the University of Central Florida
Orlando, Florida

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Thesis Chair: Susan Quelly, PhD, RN, CNE

Abstract

Preterm birth disrupts the development of the brain and other critical organs of the infant body. Since the brain is one of the last organs to finish developing during pregnancy, the risk for substantial neurological deficits increases as the gestational age decreases. One way to combat these deficits is to reconnect the preterm infant with the mother via skin-to-skin contact, also known as kangaroo care (KC). This intimate touch helps to replicate aspects of the environment that the preterm infant experienced in utero. The purpose of this literature review was to analyze the current literature to better understand the effects that KC may have on facilitating neurodevelopment of preterm infants in Neonatal Intensive Care Units (NICUs). Emphasis was placed on neurophysiologic functioning, autonomic functioning, and neurobehavioral functioning. A database search of CINAHL Plus with Full Text, PsycINFO, MEDLINE, Cochrane Central Register of Controlled Trials, and Health Source: Nursing/Academic Edition was conducted, and a total of six articles were reviewed based on their relevance and application towards this thesis. KC is a low-cost, relatively easy intervention to initiate that can have positive impacts on many aspects of preterm infant growth and maturation. There is limited research regarding the use of KC as an intervention to support neurodevelopment, especially with regards to long-term effects. Existing research supports the use of KC as an intervention to facilitate neurodevelopment in preterm infants in the NICU.

Keywords: Kangaroo Care, Skin-to-Skin Contact, Neurodevelopment, Preterm Infant, Infant Development, Neonatal Intensive Care Unit

Dedication

I would like to thank my amazing fiancé, T.J., for your unwavering support, encouragement, and love. Thank you for listening to my rants about stress, and always offering words of encouragement. Thank you for always supporting my dreams and believing in me, even when I may not believe in myself.

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I would like to thank my grandad and grandma who remind me each day that anything is possible if you put your mind to it, who taught me to cherish the little things in life and never take life for granted.

Finally, I would like to dedicate this work to my amazing mother and father whom without, I would not be the person that I am today. Without your unconditional love, support, encouragement, and guidance, I would have been able to accomplish everything I have. Thank you for being amazing role models, for always encouraging my dreams, and for all of the sacrifices you made in order for me to live the life I have.

These people have impacted my life in ways they may not even know. I love you all very much,
Tiffany

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Introduction

Kangaroo care (KC), also known as kangaroo mother care (KMC) or skin-to-skin contact (SSC) therapy, is widely used across the world as an accepted practice to facilitate bonding between mother and infant, or father and infant, and as a therapy to help stabilize and encourage growth of the infant (Cleveland Clinic, 2011). KC can be used as a therapy for full-term and preterm infants. With the increased ability to save infants born at earlier and earlier gestational ages, there is an increased need to use it in the Neonatal Intensive Care Unit (NICU) for the preterm infants. Any infant born before 37 weeks gestation, regardless of appearance or size, is immature physiologically and may experience short- and/or long-term unique health issues (Mayo Clinic Staff, 2014).

Background

Preterm birth is defined as birth occurring before the 37th week of gestation (Centers for Disease Control and Prevention [CDC], 2014). In the United States during 2012, 1 out of every 9 babies born was born preterm – an estimate that includes more than 450,000 babies (CDC, 2014). This high incidence rate is alarming because the number and severity of complications due to preterm birth is constantly increasing. Even though some of these infants (for example, late preterm infants) look like a healthy full-term infant, it is important to understand that their appearance may be misleading. An infant is not technically fully developed and ready for life outside the womb until it is full-term at 39 0/7 or 40 6/7 weeks gestation. Even though an infant born between 37 0/7 weeks and 38 6/7 weeks gestation is defined as “early term,” most of the organs are not fully developed and functioning, including the lungs and brain which are still continuing to mature (American College of Obstetricians and Gynecologists, 2013). In fact, during the 29th to 40th week of gestation, the brain volume nearly triples in size, and the preterm infant still only has two-thirds of his or her total brain volume at week 35 (Head, 2014).

Preterm birth is the leading cause of long-term neurological disabilities in infants and children (CDC, 2014). Additionally, complications associated with preterm birth are the leading cause of death in children less than 5 years of age which accounted for about 1 million children in 2013 (World Health Organization [WHO], 2014). Although preterm birth occurs before the 37th week of gestation, the definition can be broken down even further. Late preterm occurs between week 34 0/7 and 36 6/7; moderate preterm occurs between week 32 0/7 and 33 6/7; very preterm occurs between 28 0/7 and 31 6/7; and extremely preterm occurs before week 28 0/7 (WHO, 2014). Regardless of the severity, every preterm infant is at some risk for developing

complications related to their early arrival such as respiratory issues, difficulties with feeding, cerebral palsy, delayed development, and visual and auditory impairments (CDC, 2014).

There are several recommendations for mothers to decrease the risk of preterm birth, such as not smoking, avoiding alcohol and other commonly abused drugs, early and consistent prenatal care, and early treatment for any signs of preterm labor (CDC, 2014). In situations where preterm birth cannot be avoided, there are many treatments and therapies that may be used to care for the preterm infant to improve outcomes. One of the most accepted and widely used noninvasive therapies to reduce health risks associated with preterm birth is KC therapy (Cleveland Clinic, 2011).

KC involves putting the infant, with a diaper still on, onto the mother's bare chest with a blanket or mother's clothing covering the infant (Cleveland Clinic, 2011). This type of contact therapy was first seen in Columbia in response to a high death rate in preterm infants during the late 1970s and then began to be practiced in the U.S. as a therapy for preterm infants in the 1980s (Cleveland Clinic, 2011). The benefits of KC are evident in the preterm infant and the mother. Specifically, for the preterm infant, benefits of KC include heart rate stabilization, improved temperature regulation, improved breathing and oxygen saturation, increased sleep intervals, increased weight gain, increased success with breastfeeding, and an overall decreased hospital stay (Cleveland Clinic, 2011).

When basic survival needs are met, such as heart rate and oxygen saturation levels within normal limits, then the preterm infant is able to sleep better and longer. It is during these periods of sleep that the preterm infant's body is able to focus on neurodevelopment (Cleveland Clinic, 2011). Through the implementation of neuroprotective measures, such as KC, preterm infants

can achieve the stabilization and sleep needed in order for neurodevelopment to progress (Head, 2014; Scher et al., 2009).

Significance

Preterm birth is a significant problem due to the associated short-term and long-term health risks and complications. Immature organ systems are the building blocks of preterm complications. Therefore, there is a direct relationship between the severity and type of complications that may be experienced and the preterm infant's immaturity and physiologic stability (Institute of Medicine [US] Committee on Understanding Premature Birth and Assuring Health Outcomes, 2007).

As previously stated, the brain and lungs are still continuing to develop even during the 38th week of gestation and into the 39th and 40th week (American College of Obstetricians and Gynecologists, 2013). Therefore, when preterm birth occurs, the lungs and brain miss out on valuable weeks to mature. This is especially important for preterm infants' neurodevelopment progression. An underdeveloped brain can lead to an inability to process external stimuli, such as excessive light, sounds, frequent handling, and other negative stimuli present in the NICU (Head, 2014). There are also major long-term neurological disabilities that may occur due to the shortened neurodevelopment associated with preterm birth. These disabilities include social interaction impairments (such as communication and group activities), behavior problems (such as anxiety and hyperactivity), neurological disorders (such as cerebral palsy), and other disorders associated with the central nervous system (March of Dimes, 2013).

Purpose

The purpose of this review was to analyze the current literature regarding the efficacy of KC on the neurodevelopment of preterm infants in the NICU in terms of neurophysiologic functioning, autonomic functioning, and neurobehavioral functioning. Factors such as, but not limited to, sleep, sleep cycles and quality, pulmonary regulation, heart rate, temperature, and behavioral responses, were analyzed.

Methods

An integrated literature review was conducted in order to identify relevant articles using CINAHL Plus with Full Text, PsycINFO, MEDLINE, Cochrane Central Register of Controlled Trials, and Health Source: Nursing/Academic Edition. Key search terms used included “kangaroo care”, “skin to skin”, SSC, KMC, “kangaroo mother care”, AND “neonatal intensive care unit”, NICU, newborn, AND neuro*. Articles were limited to English language peer-reviewed research studies published between 2005 and 2015. Inclusion criteria required that articles involved studies analyzing outcomes associated with KC, or skin to skin care, implemented with preterm infants in the NICU. Research articles were excluded if the study did not report neurodevelopment outcomes, included intraventricular hemorrhage severity greater than II, or if the KC was not with the mother.

Results

Using key search terms, adding more search terms, and applying limiters to narrow down relevant articles, a total of six articles meeting the inclusion and exclusion criteria were retrieved in this search. The findings from the six articles suggest that KC with preterm infants facilitates improved neurodevelopment, with some improvements continuing into adolescence.

Neurophysiologic Functioning

Neurophysiologic functioning refers to the how to brain and nervous system work and communicate (Neurophysiology, n.d.). This domain of functioning can be assessed using functional neuroimaging, which refers to measuring brain function with the use of neuroimaging technologies such as electroencephalography (EEG), transcranial magnetic stimulation (TMS), or positron emission tomography (PET) (Crosson et al., 2010). One study analyzed sixteen EEG studies from eight preterm infants and found that preterm infants who received KC experienced significantly greater EEG complexity of the right hemisphere, along with areas in the left and right parasagittal regions, when compared to preterm infants who did not receive KC (Scher et al., 2009). The preterm KC group also experienced greater complexity of three specific areas of the right hemisphere when compared to both the preterm non-KC group and the full-term non-KC group (Scher et al., 2009). However, the preterm KC group lacked complexity of the posterior left hemisphere compared to the full-term non-SSC (Scher et al., 2009).

Several years later, an analysis using a procedure described as “approximate and sample entropy to quantify predictability in the EEG time series” was used to evaluate the effects of KC on regularity and predictability of EEG sleep (Kaffashi, Scher, Lidington-Hoe, & Loparo, 2013). This analysis further showed that preterm infants who experienced KC had significantly

improved neurodevelopment by comparing the EEG results from the 2009 study (Scher et al., 2009) to control groups from earlier studies (Lundington-Hoe et al., 2006; Scher et al., 1997). The findings suggested that the preterm infants who did receive KC had greater complexity, or decreased predictability, in five regions on the brain. These regions included specific parts of the right hemisphere, and right and left areas of the parasagittal region, when compared to the preterm infants who did not receive KC (Kaffashi et al., 2013). The posterior left hemisphere was found also to have less complexity in the preterm KC group compared to the full term non-KC group (Kaffashi et al., 2013).

EEG studies were used to examine how KC supports neurodevelopment in preterm and full term infants (Kaffashi et al., 2013; Scher et al., 2009), whereas another study utilized TMS to analyze the effects of KC on neurodevelopment (Schneider, Charpak, Ruiz-Pelaez, & Tessier, 2012). TMS activates the corticospinal cells of the brain when it is applied over the primary motor cortex of the brain. This cell activation then produces a response referred to as motor-evoked potential (MEP) in the muscles of the contralateral side and can be measured (Schneider et al., 2012). This study applied TMS over the primary motor cortex of the brain of 39 adolescents who had been born preterm and found that the adolescents who had received KC as preterm infants had TMS outcomes that were more similar to adolescents who were born at full-term relative to adolescents who were born preterm and did not receive KC (Schneider et al., 2012). Decreased MEP latency indicates improved primary motor cortex synchronization. This was seen in preterm infants who received KC compared to preterm infants who did not receive KC (Schneider et al., 2012). Further, the improved primary motor cortex synchronization in the

preterm infants with KC was not significantly different relative to the infants who were born at full-term and did not receive KC (Schneider et al., 2012).

The decrease in MEP latency was also associated to the time spent during each KC session (Schneider et al., 2012). Likewise, in the preterm group who received KC, the interhemispheric inhibition was longer, the latency was shorter, and the duration was longer than the latency period compared to the preterm group who did not receive KC (Schneider et al., 2012). These results indicated a faster transfer time between hemispheres, better control between the two hemispheres, and overall properly working interhemispheric pathways suggesting that KC facilitates improved neurodevelopment (Schneider et al., 2012). When the preterm KC group was compared to the full term non-KC group, these results were similar with no significant difference (Schneider et al., 2012).

Autonomic Functioning

Autonomic functioning refers to any changes involving the autonomic nervous system, such as respiratory changes and cardiovascular changes. Changes in sleep pattern will also be discussed in this section because children who have higher autonomic functioning have been shown to have better sleep quality (El-Sheikh, Erath, & Bagley, 2013).

In addition to the findings regarding neurophysiologic functioning, Ludington-Hoe et al. (2006), found that infants who received KC experienced a significantly lower number of arousal, rapid eye movements (REMs), and indeterminate sleep, along with increased quiet sleep compared to infants who did not receive KC. A study published a few years later further supported these results (Scher et al., 2009). The findings showed that preterm infants who experienced KC had fewer REMs ($p < .0001$), longer sleep cycles ($p < .01$), a higher percentage

of quiet sleep ($p < .0001$), and a lower respiratory ratio compared to both non-KC groups, indicating greater respiratory regularity (Scher et al., 2009). However, the number of arousals was greater ($p < .0003$) in the preterm infants who received KC compared to the two non-KC groups, which reveals mixed findings with the earlier study (Lundington-Hoe, 2006; Scher et al., 2009). A secondary data analysis of the 2009 study found similar results using a different measurement that demonstrated an correlation between increase in EEG sleep complexity and improved neurodevelopment (Kaffashi et al., 2013).

A longitudinal study followed 126 mothers and their preterm infants over the course of ten years (Feldman, Rosenthal, & Eidelman, 2014). This study revealed that the preterm infants who received KC experienced higher baseline respiratory sinus arrhythmia (RSA) also experienced a more organized sleep-wake cycle, which indicated an increase in function of the autonomic nervous system compared to the preterm non-KC group (Feldman et al., 2014). At the term age assessment and ten year assessment, the baseline RSA and sleep organization continued to improve, suggesting that KC has lasting effects of at least ten years on the function of the autonomic nervous system (Feldman et al., 2014).

Neurobehavioral Functioning

Neurobehavioral functioning refers to the manner in which the brain influences learning, emotion, and behavior which can be altered due to preterm birth (Gorzilio, Garrido, Gaspardo, Martinez, & Linhares, 2015; National Cancer Institute, n.d.). In addition to the findings regarding neurophysiologic and autonomic functioning, one study found that premature infants who received KC experienced significant mental development upon assessments at 6 months, 12 months, and 24 months of age (Feldman et al., 2014). Also, the preterm infants who received KC

experienced higher executive functioning at the five year and ten year assessments when compared to the preterm non-KC group (Feldman et al., 2014). These findings further suggest that KC has long-term benefits regarding neurodevelopment and cognitive control.

The Assessment of Preterm Infant Behavior (APIB) was used to compare preterm infants who were encouraged to receive KC, premature infants who were encouraged to received blanket holding, and preterm infants who received no encouragement regarding holding style (Neu, Robinson, & Schmiede, 2013). The preterm infants who received KC had similar outcomes to those who were blanket held. Also, of the eight different categories in the assessment, the results of both the KC group and the blanket held group were scored higher in the majority of the assessment categories compared to the control group that received no specific type of holding intervention (Neu et al., 2013). One instance in which the KC group and the blanket held group score significantly higher than the control group was in the assessment category of Robust Crying (Neu et al., 2013). This indicated that preterm infants who were held either kangaroo style or in a blanket were able be consoled more quickly back to a calm state after being in a robust crying state, suggesting better cognitive control (Neu et al., 2013).

The report of better cognitive control potentially being associated with KC in this study (Neu et al., 2013) was further supported when a study published a year later reported that preterm infants who received KC demonstrated greater improvement in cognitive control over the course of 10 years (Feldman et al., 2014). The behavioral-based results from the APIB are consistent with the technologically-based results from the study that used multiple measures to quantify cognitive control over the first ten years of life in preterm infants who received KC (Feldman et al., 2014; Neu et al., 2013).

Discussion

Factors affecting neurodevelopment that were investigated in this literature review included neurophysiologic functioning, autonomic functioning, and neurobehavioral functioning. The overall findings of the articles reviewed revealed that KC positively influenced, and in some cases accelerated, neurodevelopment and maturation in preterm infants when compared to other preterm infants who did not experience KC. The one exception to this claim was seen with KC being compared to blanket holding (Neu et al., 2013).

Neurophysiologic Functioning

Based on the results, neurophysiologic growth and functioning were increased and accelerated in preterm infants who experienced KC when compared to preterm infants who did not experience KC (Kaffashi et al., 2013; Scher et al., 2009). Even though both studies analyzed data from the same relatively small samples, the results are still noteworthy because both studies analyzed the results using two different methods and their outcomes consistently supported that KC positively influenced an increase in neurophysiologic development. Also, the secondary data analysis utilized approximate and sample entropy, which quantified the direct relationship of complexity and predictability in the time series under the idea that if two sequences are similar for a number of points, then they will remain similar at the next point (Kaffashi et al., 2013). Therefore, by using approximate and sample entropy to quantify the results, the findings suggested that there is accelerated neurophysiologic development in preterm infants who experienced KC than preterm infants who did not experience KC (Kaffashi et al., 2013). Both studies reported less complexity in the posterior left hemisphere, which could potentially be attributed to more matured cortico-cortical connections existing in early life with preference to

the right hemisphere as opposed to the left hemisphere (Scher et al., 2009). Therefore, the researchers concluded that the finding of less complexity on the left side of the hemisphere may not be due to KC having a negative effect on the brain, but rather the brain's anatomic immaturity and preference to mature the right side earlier than the left (Scher et al., 2009).

The developmental difference between the preterm KC group (Scher et al., 2009) and the preterm non-KC control group (Ludington-Hoe et al., 2006) may have been influenced by differing environments in the two NICU settings, such as variations in noise, lights, and other external stimuli that could not be controlled, thus affecting neurophysiologic development. Also, the standards of care may have also been different between the two groups since the KC group was studied at a different facility during a different year than the non-KC group, and evidence and policies regarding patient care continue to evolve and change as research findings are disseminated. This is also a consideration for the Kaffashi et al. (2013) secondary analysis study since the data sets for the two non-KC control groups were obtained from previous studies conducted in 1997 (Scher et al., 1997) and 2006 (Ludington-Hoe et al., 2006). In addition, even though the study states that the protocol and conditions for control group from the earlier study (Ludington-Hoe et al., 2006) and the conditions for preterm KC sample (Scher et al., 2009) were the same, and both results were analyzed by the same researcher, there may have been some unidentified or unknown confounding factors.

The positive effects of KC on neurodevelopment are also evident in the adolescent years when comparing differences in adolescents who experienced KC as a preterm infant and adolescents who did not experience KC as a preterm infant (Schneider et al., 2012). This

suggested that not only may KC positively influence neurodevelopment, but KC may have the potential to also positively influence neuroplasticity development (Schneider et al., 2012).

Autonomic Functioning

Results supporting the claim that KC facilitates more quiet sleep, decreased REMs, decrease indeterminate sleep, and decreased arousals were reported (Ludington-Hoe et al., 2006). Similar findings also reported more stable heart rates, lower respiratory ratio, and more complex EEG sleep studies in preterm infants who received KC compared to infants who did not receive KC using linear and complexity analysis (Scher et al., 2009). However, these two studies reported mixed findings regarding the number of arousals during KC. The earlier study (Ludington-Hoe et al., 2006) reported significantly lower number of arousals experienced during KC, whereas the later study (Scher et al., 2009) reported increased number of arousals during KC. A possible reason as to why this may have occurred could be that the earlier study analyzed EEG results from one session of KC, whereas the later study analyzed EEG results from two different KC sessions potentially allowing for more insight into the effects of KC. More research needs to be conducted analyzing EEGs of more than two session of KC and the number of arousals experienced in order for a conclusion to be made.

The findings from the secondary data analyses reflected similar findings as the 2009 study while using approximate and sample entropy to support that preterm infants who received KC had experienced more organized sleep and more complex EEG studies with KC when compared to the preterm infants who did not receive KC (Kaffashi et al, 2013). This suggested an increase in neurophysiologic maturation and improvement in autonomic functioning (Kaffashi et al., 2013). A few variables to consider as to why this difference occurred, other than from the

influence of KC, include the type of equipment used and the amount of external stimuli. For example, it is unknown as to what type of mattress was used, which could have an effect on sleep behaviors, and it is also unknown as to whether or not the amount of noise, light, and additional external stimuli was consistent for each group since the preterm KC group was analyzed at a different facility than the preterm non-KC group.

KC was also reported to be associated with improved RSA, indicating an increase in autonomic functioning. The main consideration regarding KC and autonomic functioning is that the preterm infant is already deficient when compared to a full term infant because many preterm infants miss the 33rd gestation week in which the heart rhythm and vagal tone normally mature (Feldman et al., 2014). Also, the autonomic nervous system is greatly influenced by the physiologic and behavioral rhythms of the mother (Feldman et al., 2014). Therefore, facilitating improvements of the autonomic nervous system is essential, and this can be achieved through KC (Feldman et al., 2014). This facilitation in autonomic nervous system function can be exhibited via improvements of RSA, and have long-term positive effects for the preterm infant (Feldman et al., 2014).

Neurobehavioral Functioning

KC appears to have lasting effects on preterm infants through the age of 6 months and up to ten years (Feldman et al., 2014). Furthermore, there was an increase in cognitive development and executive functions, such as cognitive control, cognitive flexibility, and working memory (Feldman et al., 2014). This claim that KC facilitates better cognitive control was consistent with findings in another study in which preterm infants who received KC had better outcomes when assessed using the APiB (Neu et al., 2013).

The study that utilized the APIB also explored the use of blanket holding in addition to kangaroo holding, and the findings of the preterm infants who were held with a blanket had similar results to the preterm infants who were held KC style (Neu et al., 2013). A reason for this similarity could be due to the methodology and measurements used. This study assessed the behavior of the preterm infants using the APIB which involved a trained examiner to stimulate the preterm infants with lights and sounds, such as a rattle or bell, in order to elicit a response (Neu et al., 2013). The examiner also tested reflexes to assess tactile capabilities by making various faces and sounds at the preterm infant to assess visual and auditory abilities (Neu et al., 2013). Rather than using more complex technology to collect data, this study measured outcomes based on the assessment of an individual examiner which may have involved some subjective evaluation despite training.

Therefore, more general assessments were made regarding the effects of KC and blanket holding, and less noticeable effects, or the effects that cannot be visually seen such as neurophysiology, were not accounted for in this assessment. This type of measurement found similar outcomes between KC and blanket holding possibly because of the likelihood that any type of holding would elicit a positive response compared to no holding practice. If this study had been conducted using more complex technology to assess the activity of the brain, then it is possible that the results would have reflected more of a difference between KC and blanket holding. Another factor to consider with this study is that it is unknown if the same trained individual examined all of the preterm infants for each assessment. The study states that there were two examiners – one of whom was blind to the group assignments and scored the assessment, and the other of whom scored the assessments by watching a video of the exam (Neu

et al., 2013). However, the study does not state whether or not the same individual was Examiner One or Examiner Two for all assessments scoring. Also, the nurse that encouraged, or did not encourage, a holding practice, may have been a different nurse from week to week, and the mothers may or may not have been consistent with adhering to their assigned holding practice. Additional research is needed using more objective measurements to confirm similarities or differences in neurobehavior between blanket holding versus KC in preterm infants.

Other Considerations

The articles reviewed in this literature review all discussed preterm infants who were generally healthy, with the exception of being born preterm. With that, a question is raised regarding if KC is effective, or even safe, with premature infants who are not particularly healthy, and more “vulnerable.” This is the exact question that Carbasse et al. (2013) attempted to answer. The term “vulnerable preterm infants” refers to preterm infants who are unstable and may or may not be attached to ventilatory support (Carbasse et al., 2013). The use of KC on vulnerable preterm infants proves to be challenging, and it is not yet a widely accepted practice (Carbasse et al. 2013). In their study, the goal was to assess if KC with vulnerable preterm infants was first of all safe, and secondly if it was effective. They ultimately reported that KC is a safe practice with vulnerable preterm infants in the NICU, and it is also effective, even if the vulnerable preterm infant is on ventilatory support (Carbasse et al. 2013). This study is influential for the care of vulnerable preterm infants because the earlier KC can be initiated, the sooner it can begin facilitating, and perhaps accelerating, growth and development while potentially decrease the length of stay.

Although KC has been shown to be effective in preterm infants to facilitate and improve their growth and development, it is also effective in improving maternal attachment, maternal behavior, and the maternal-infant relationship (Feldman et al., 2014). This is important to consider given that RSA and maternal behaviors were found to be interrelated and had long-term effects such as preterm infant improvement in physiology and executive functions, as well as improved mother-child interactions at the ten year assessment (Feldman et al., 2014).

In terms of long-term effects on neurodevelopment, two studies suggested that KC may play a critical role (Feldman et al., 2014; Schneider et al. 2012). If KC with preterm infants is shown to significantly contribute to better long-term neurodevelopment outcomes, the ramifications for improvement in overall quality of life and reduced lifelong healthcare costs may be substantial. Therefore, there is a need for further research to be conducted regarding the long-term benefits of KC regarding neurodevelopment and other growth and developmental aspects.

Nursing Implications

Research regarding the effects of KC on neurodevelopment in preterm infants in the NICU has significant implications for nursing practice. A nurse is expected to perform physical assessments, provide education, administer medications, analyze patient information, coordinate care, and advocate for their patient to ensure that he or she is receiving the best care possible (ANA, n.d.). Nurses caring for preterm infants in the hospital setting are ideally positioned to educate the mothers and fathers about the potential benefits of KC. Nurses have the most contact with these tiniest patients and consequently have the most influence on encouraging and promoting KC. By initiating and supporting KC, a nurse promotes health and wellness of the preterm infant in regards to overall physiological, behavioral, and psychological development (Head, 2014). The nurse will be responsible for monitoring the preterm infants before, during, and after KC to ensure that the intervention is safe and effective for the preterm infant and not exposing the infant to additional stress. In addition to clinical nursing implications regarding the wellness and development of preterm infants, nurses have the ability to also positively influence maternal health and wellbeing (Feldman et al., 2014).

There is evidence that preterm infants may benefit from KC with their father as well as their mother, and the father may experience benefits as well (Blomqvist, Rubertsson, Kylberg, Jöreskog, & Nyqvist, 2012; Erlandsson, Dsilna, Fagerberg, & Christensson, 2007). Nurses encouraging fathers to participate in KC may be particularly important if the mother is too ill or otherwise unable to provide KC to their preterm infant. This practice may also promote bonding between the father and his preterm infant.

Conclusion

Preterm birth complications are credited with being the leading cause of death in children under the age of five (WHO, 2014). Brain development is disrupted when an infant is born preterm (Feldman et al., 2014). This disruption can lead to a number of neurodevelopment alterations such as suppression of neurogenesis, decreased myelination, disturbances of white matter, decreased complexity and connectivity, decreased autonomic functioning, and altered sleep patterns (Feldman et al., 2014) (Scher et al., 2009).

These brain anomalies often continue to affect child and adolescent neurodevelopment and functioning (Feldman et al., 2014), which has potential implications for influencing health and healthcare costs long term. While KC is most often correlated with improved physiologic functioning, such as with improved heart rate, respiratory rate, and increased oxygenation (Cleveland Clinic, 2011), its positive effect on brain maturation cannot be ignored. Recent research regarding KC and neurodevelopment provides evidence that KC is beneficial, safe, and promotes neurodevelopment in preterm infants in the NICU. Preterm infants in the NICU are usually administered numerous pharmacological interventions to keep them alive and make them comfortable. KC is a nonpharmacological intervention that is relatively easy for a nurse to encourage and facilitate in order to promote improved or accelerated neurodevelopment in preterm infants (Ludington-Hoe et al., 2006).

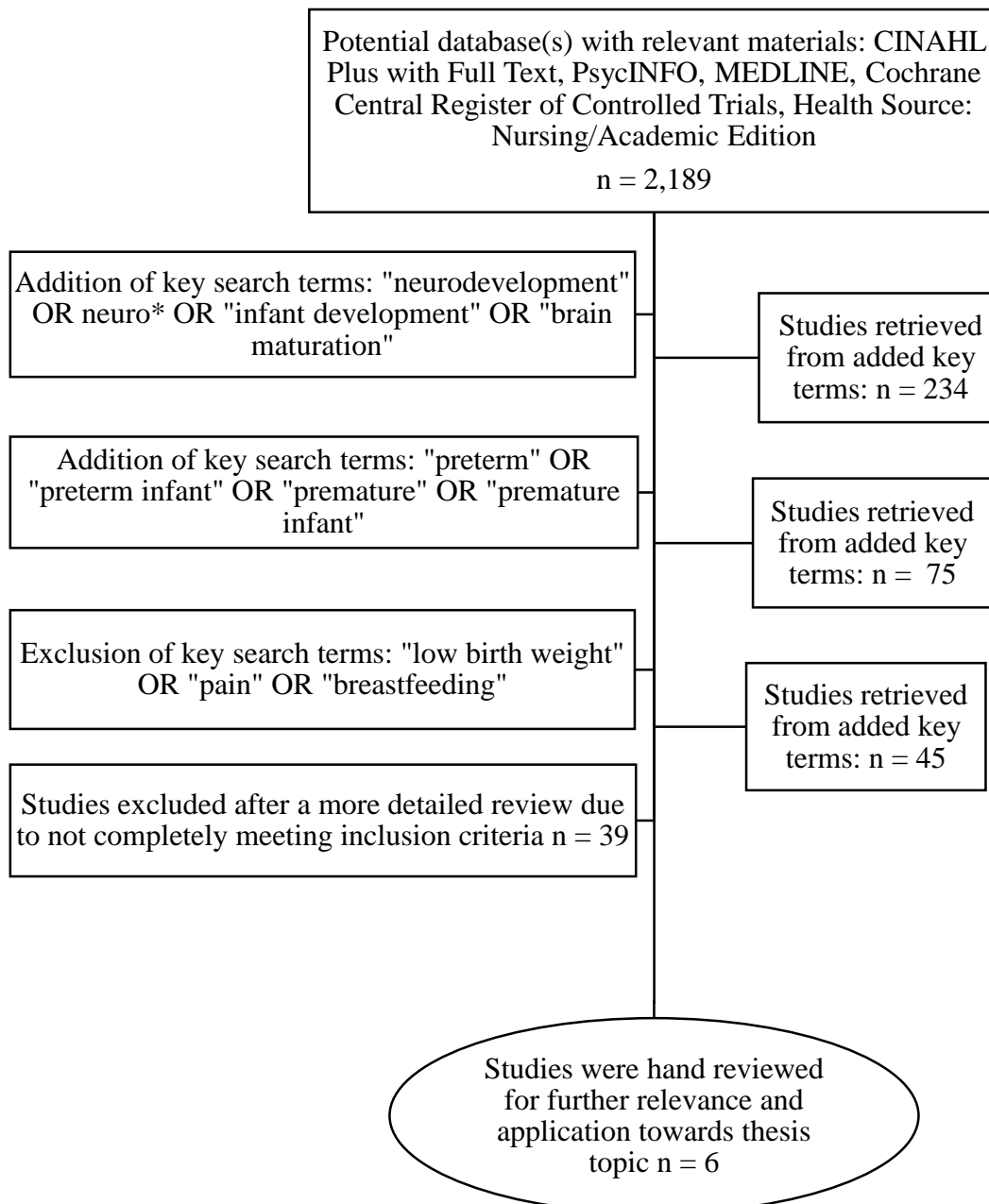
Appendix A: Figures

Appendix A: Figures

Figure 1.1

Key terms: (MH "Kangaroo Care") OR "kangaroo care" OR "skin-to-skin" OR "skin to skin" OR "kangaroo mother care" OR "mother care" OR "holding practice" OR "SSC" OR "KMC"

Limiters used: Published Date: 01/01/2005 – 09/31/2015; Scholarly (Peer Reviewed) Journals; English Language; Research Article



Appendix B: Tables

Appendix B: Tables

Table 1

Article	Design	Sample size/age	Method	Results	Key Findings
Feldman, R., Rosenthal, Z., & Eidelman, A. I. (2014). Maternal-preterm skin-to-skin contact enhances child physiologic organization and cognitive control across the first 10 years of life. <i>Biological Psychiatry</i> , 75(1), 56-64. doi:10.1016/j.biopsych.2013.08.012	Quantitative; Longitudinal	N = 146: two groups 73 preterm infants born $25 \leq 34$ wks received KC; 73 preterm infants in control group received no KC and basic incubator care	73 infants received KC for 14 days; outcomes were compared to control group that received no KC; maternal attachment assessed by coding actions observed via videotape	KC \uparrow autonomic functioning, organized sleep, and cognitive development, throughout the first 10 years of life while also \uparrow maternal attachment and \downarrow maternal anxiety	Early KC has positive long-term effects on physiologic and behavioral development for preterm infants
Kaffashi, F., Scher, M. S., Ludington-Hoe, S. M., & Loparo, K. A. (2013). An analysis of the kangaroo care intervention using neonatal EEG complexity: A preliminary study. <i>Clinical Neurophysiology</i> , 124(2), 238-246. doi:10.1016/j.clinph.2012.06.021	Quantitative; Randomized control trial	N = 134: 8 born ≤ 28 wks with KC; 78 preterm non-KC control group studied at corrected term; 48 full term non-KC control group	16 EEG-sleep studies analyzed; 8 wks of KC; outcomes compared to two non-KC groups using time series	KC group showed \uparrow brain complexity and development when compared to non-KC	KC may \uparrow brain maturation in preterm infants when compared to a non-KC group. Time series methods may be useful to assess other interventions aim

			measures of predictability		at neurodevelopment
Ludington-Hoe, S., Johnson, M., Morgan, K., Lewis, T., Gutman, J., Wilson, P., & Scher, M. (2006). Neurophysiologic assessment of neonatal sleep organization: preliminary results of a randomized, controlled trial of skin contact with preterm infants. <i>Pediatrics</i> , 117(5), e909-23 1p. doi: 10.1542/peds.2004-1422	Quantitative; Randomized control trial	N = 28: 14 with KC; 14 without KC as control group; both groups born < 32 wks PMA	EEG recorded at pre and post feedings: Non-KC fed in incubator, KC fed by mothers	KC group showed significantly ↓ arousals, REMs, and IS compared to control; KC group experienced ↑ QS %	KC may effect enhance sleep organization, and therefore positively affect neurodevelopment
Neu, M., Robinson, J., & Schmiede, S. J. (2013). Influence of Holding Practice on Preterm Infant Development. <i>MCN: The American Journal Of Maternal Child Nursing</i> , 38(3), 136-143 8p. doi:10.1097/NMC.0b013e31827ca68c	Quantitative; Randomized control trial	N = 87; 3 groups of infants born between 32 and 35 weeks gestation: KC, blanket, control with no encouragement for holding	Weekly nurse visit for 8 wks; KC and blanket groups had holding encouraged; control had a brief non-encouraging visit; infants then assessed using the APIB between 40 and 44 wks PCA	KC preterm infants held the longest per day, had higher assessment scores in Robust Crying than blanket or control, and mostly had scores that were at least as high as control. Blanket style scored similar to KC	Preterm infant behavioral development and organization may be positively influenced with the use of KC

Scher, M. S., Ludington-Hoe, S., Kaffashi, F., Johnson, M. W., Holditch-Davis, D., & Loparo, K. A. (2009). Neurophysiologic assessment of brain maturation after an 8-week trial of skin-to-skin contact on preterm infants. <i>Clinical Neurophysiology</i> , 120, 1812-1818. doi:10.1016/j.clinph.2009.08.004	Quantitative; Randomized control trial	N = 134: 8 born \leq 28 wks with KC; 78 preterm non-KC control group studied at corrected term; 48 full term non-KC control group	16 EEG-sleep studies analyzed; 8 wks of KC; outcomes compared to the two non-KC groups	KC preterm infants experienced \uparrow sleep cycles, \uparrow quiet sleep, \downarrow REMs, \uparrow pulmonary regularity, \uparrow complexity in right hemisphere compared to preterm non-KC, and were developmentally more similar to full-term non-KC group	\uparrow brain maturation in preterm infants that experienced KC
Schneider, C., Charpak, N., Ruiz-Peláez, J., & Tessier, R. (2012). Cerebral motor function in very preterm-at-birth adolescents: a brain stimulation exploration of kangaroo mother care effects. <i>Acta Paediatrica</i> , 101(10), 1045-1053 9p. doi:10.1111/j.1651-2227.2012.02770.x	Quantitative, Retrospective	N = 66; 3 adolescent groups: 39 born < 33 wks with KC; 18 born < 33 wks without KC; 9 born > 37 wks	TMS applied to assess motor planning abilities between the two brain hemispheres	Preterm born with KC: developmentally more similar to non-KC full term born, \uparrow efficiency of motor pathways, \uparrow control between hemispheres, and better outcomes than preterm born with no KC.	KC facilitates \uparrow connectivity and efficiency of the brain in preterm infants through adolescent age

KC = Kangaroo Care; EEG = electroencephalogram; PMA = Post Menstrual Age; REMs = Rapid Eye Movements; IS = Indeterminate Sleep; QS = Quiet Sleep; APIB = Assessment of Preterm Infant Behavior; PCA = Post Conceptual Age; TMS = Transcranial magnetic stimulation

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