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**PARENT-INFANT  
SKIN-TO-SKIN CONTACT  
STUDIES**

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Institutet**

Stockholm 2012

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Published by Karolinska Institutet. Printed by Universitetservice US-AB

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ISBN 978-91-7457-685-6

*We are now, or will soon be, in a position to begin mapping the relations between individual differences in early attachment experiences and changes in neurochemistry and brain organization. In addition, investigation of physiological “regulators” associated with infant–caregiver interactions could have far-reaching implications for both clinical assessment and intervention.*

*Mary Main, 1999*

## ABSTRACT

**The overall aim** of this thesis was to investigate the impact of early skin-to-skin contact on maternal, paternal and infant interaction immediately after Cesarean section and personality profile in mothers. Furthermore, it was to study skin-to-skin contact between mothers and infants as a method to solve severe latch-on breastfeeding problems, even weeks after birth.

**Methods:** (I-III) Thirty-seven healthy infants born to primiparas were randomized to 25 minutes of skin-to-skin contact with either their fathers or mothers after five minutes of skin-to-skin contact with their mothers after birth or a group. The interaction of newborns was recorded on a videotape. Interaction behaviours were compared between the skin-to-skin groups and their controls. Blood samples were taken for analysis of oxytocin with radio-immuno-assay in both mothers and fathers every five minutes for the first 45 minutes after birth and then every 15 minutes, up to two hours after childbirth. The mothers were asked to fill in the Karolinska Scale of Personality (KSP).

(IV) 103 healthy mother-infant pairs with severe latch-on problems were randomly assigned to breastfeeding during skin-to-skin contact (SSC-group) or not (control group) after screening for eligibility. Breastfeeding counselling was given to both groups according to a professional standardised model. Mothers completed a self-rating instrument Breastfeeding Emotional Scale (BES) before and after the breastfeeding session mothers were followed up to four months.

**Results:** Infants' soliciting sounds increased over time ( $p=0.032$ ). Fathers in skin-to-skin contact performed more soliciting responses than control fathers ( $p=0.010$ ) (I). Infants in skin-to-skin contact with mothers cried significantly more than infants in skin-to-skin contact with fathers ( $p=0.002$ ) and girls cried more than boys in skin-to-skin-contact with either parent ( $p=0.02$ ). Mothers touched girls less than boys ( $p=0.038$ ). Fathers directed less speech towards girls compared to boys ( $p=0.042$ ) (II). Girls initiated breastfeeding behaviour earlier than boys in skin-to-skin-contact with either parent ( $p=0.027$ ). Infants started to breastfeed significantly earlier if they had uninterrupted skin-to-skin contact with mothers during the first 5-30 minutes ( $p=0.018$ ) (II). Both mothers and fathers

showed a slight rise in oxytocin levels after birth irrespective of being in skin-to-skin contact with the infant or not. In mothers, oxytocin infusion alone caused lower scores in detachment ( $p=0.045$ ) and also in somatic anxiety ( $p=0.017$ ). In contrast, skin-to-skin contact mothers with oxytocin infusion showed higher scores on somatic anxiety than their controls ( $p=0.022$ ) (III). The infants with latch-on problems began to breastfeed after significantly shorter time than infants in the control group, ( $p=0.020$ ) and had more positive breastfeeding experiences according to the BES after the intervention than mothers in the control group ( $p=0.022$ ) (IV).

### **Conclusion:**

Skin-to-skin contact immediately after a caesarean section enhances parental-infant interaction, but we did not find differences in mean oxytocin levels between groups in skin-to-skin contact or not. The plasma oxytocin levels in both mothers and fathers showed a slight rise lasting for 60 minutes after birth irrespective of being in skin to skin contact with the infants or not. These data suggest that there might be a period immediately after birth, when both mothers and fathers have high oxytocin levels, which might facilitate bonding to the newborn.

Oxytocin infusion may have a potentiated effect on maternal plasma oxytocin levels when in skin-to-skin contact and may contribute to lower self-reported scores on the detachment scale and the somatic anxiety scale in KSP two days post partum. Uninterrupted skin-to-skin contact with the mother accelerates the time point for the infants' first breastfeeding after birth and skin-to-skin contact can help infants to restore their innate breastfeeding program and achieve satisfactory breastfeeding, even months after birth.

Key words: skin-to-skin contact, caesarean section, parent-infant interaction, sex-differences, breastfeeding, latch-on problems, oxytocin, personality

## LIST OF PUBLICATIONS

- I. Velandia M , Uvnäs-Moberg K, Nissen E. Matthiesen, A-S, Uvnäs-Moberg K, Nissen E. Onset of Vocal Interaction Between Parents and Newborns in Skin-to-skin Contact Immediately After Elective Cesarean Section, *BIRTH* 37:3 September 2010
- II. Velandia M , Uvnäs-Moberg K, Nissen E. Sex differences in newborn interaction and in mother and fathers during skin-to-skin contact immediately after birth, *Acta Paediatrica Online* November 2011
- III. Velandia M , Uvnäs-Moberg K, Nissen E. Oxytocin levels in Parents during Skin-to-Skin contact with their Newborn Infant Immediately after Caesarean Section. (Manuscript)
- IV. Svensson K, Velandia M, Matthiesen A-S, Welles Nyström B, Widström A-M. Effects of mother-infant skin-to-skin contact on severe latch-on problems in infants during the first months after birth (under review *International Breastfeeding Journal*).

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## LIST OF ABBREVIATIONS

SSC	Skin-to-skin contact
SSCM	Skin-to-skin contact mothers
SSCF	Skin-to-skin contact fathers
CONM	Control mothers
CONF	Control fathers

### Relevant terms and definitions

Terms	Definitions
Breast-seeking behaviour	Rooting and breast massaging movements
Exclusive breastfeeding	The infant receives nothing but milk from the breast, vitamin D and eventual medication
Hands-on latch intervention	Hospital staff, another person or relative uses their own hands to try to attach the infant to the breast with a grip around the infant's neck and a grip around the mother's breast/nipple sometimes using more or less force
Latch-on/Latching	The infant is sustained attached to the breast with a wide open mouth over the nipple and the areola or parts of the areola and tongue in close contact with the lower part of the areola
Latching Regularly	The mother perceives that the infant wants to breastfeed; the infant responds by latching-on the breast when it is offered
Nipple shield	Small plastic or rubber device shaped like the nipple that is placed over the nipple before latching
No separation	Mother and infant have skin-to-skin contact directly after birth and stay together during the first hour
Partial breastfeeding	Breastfeeding occurs regularly but the infant is also given supplementation or has started to eat solid food
Pre-feeding behaviour	Breast-hand-mouth coordinating movements, soliciting sounds and breast-seeking behaviour
Self regulation	Infants effort to regulate themselves to become calm and relaxed with regard to motor system balance and sleep organization
Skin-to-skin contact	Skin-to-skin contact is defined when the naked newborn is placed on his or her mother's or father's naked chest, allowing contact with the nipple.
Sucking	The infant is sucking the breast with rhythmic movements with pauses in between



# **1 INTRODUCTION**

The present thesis focuses on the effects of skin-to-skin contact after a caesarean section and skin-to-skin contact as a possible method for mother infant dyads to restore the newborns biological behavior to search for the breast and start sucking in cases where severe breastfeeding problems have occurred, even months after birth.

Worldwide the caesarean section rates are escalating and are now almost double the optimal recommended by World Health Organization (WHO 1985).

In Sweden the proportion of caesarean section has increased from 10% to approximately 18% over the last ten years, according to The National Board of Health and Welfare (2011).

The demand for an elective caesarean section has increased in Sweden without any particular concerns about the effects on parent-infant interaction and breastfeeding (Wiklund, Edman et al. 2007).

## **1.1 MATERNITY POLICY**

Since 1991 the Baby Friendly Hospital Initiative (BFHI) has been launched globally by WHO and UNICEF with the purpose to protect breastfeeding and encourage early mother-infant interaction immediately after birth(Ten Steps to Successful Breastfeeding) , a global strategy for breastfeeding protection and support (1989). This strategy has been implemented in all maternity wards in Sweden already in 1996 but only for vaginally delivered newborns.

After cesarean section there is a lack of policy programs for continuation of maternity care. During a caesarean section neither the mother, nor the father routinely keep their infant in skin-to-skin contact and the first contact and breastfeeding are delayed which later may lead to latch-on problems and parental stress (Whichelow 1982; Samuels, Margen et al. 1985; Rowe-Murray and Fisher 2002).

Separation or delay in the first sight of the baby could complicate (Christensson, Siles et al. 1992; Bystrova, Ivanova et al. 2009) and postpone the beginning of the mother's bonding to the infant (Widstrom, Wahlberg et al. 1990).

## **1.2 THEORETICAL BACKGROUND**

It is well known that during the first two hours after an uncomplicated vaginal birth, the babies are in an alert state which could facilitate the parent-infant interaction, probably due to the release of catecholamine (Faxelius, Hagnevik et al. 1983). Directly after birth the healthy newborn baby put in skin-to-skin contact on his/her mother's chest exhibits a sequential behavior aimed at reaching the nipple and start to sucking (Widstrom, Ransjo-Arvidson et al. 1987).

In mammals, oxytocin is known to play a role in maternal bonding (Keverne and Kendrick 1994; Kendrick 2000; Poindron 2005). Since in human mothers oxytocin levels also rise after birth it is possible that oxytocin is released in parallel into the brain and in the blood during the postpartum period to influence maternal adaptation (Uvnas-Moberg, Johansson et al. 2001). Different medical interventions during birth may lead to decreased oxytocin release in the long-term. Mothers who undergo caesarean section show a reduced release of oxytocin two days after birth in connection with a breastfeeding session (Nissen, Uvnas-Moberg et al. 1996).

After a caesarean birth, fathers could make a definite contribution to care for the infant, if the mother is not available. Paternal skin-to-skin contact increases infant skin temperature (Ludington-Hoe, Hashemi et al. 1992; Christensson 1996) and reduces infants' crying (Erlandsson, Dsilna et al. 2007), however very little is known about early father-infant interaction immediately after birth (Rodholm and Larsson 1979).

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### **1.2.1 Skin-to-skin contact**

At birth, newborns have a capacity to respond to sensory stimuli from the outside world and their inborn behavior is triggered and modulated by sensory cues such as maternal breast odor (Varendi and Porter 2001), warm temperature and skin-to-skin contact (Christensson, Siles et al. 1992), voices (DeCasper and Fifer 1980), and facial expressions from the parents (Meltzoff and Moore 1977).

Skin-to-skin contact after birth is known to promote the infants' regulation of temperature and metabolic adaptation and maintenance of glucose blood levels (Christensson, Siles et al. 1992) compared to infants not having skin-to-skin contact or those being separated from their parents (Bystrova, Matthiesen et al. 2007). Thus, skin-to-skin causes a down regulation of stress reactivity (Bystrova, Widstrom et al. 2003).

Olfactory cues seem to attract and orient the baby towards the mother's breast when left in skin-to-skin contact. Under normal conditions natural maternal breast odors reduce crying (Doucet, Soussignan et al. 2007) and elicit approach behavior in newborns even in infants in a cot during an experimental situation (Varendi and Porter 2001). An infant crying has also been shown to increase the mother's breast temperature (Vuorenkoski, Wasz-Hockert et al. 1969). The increase of breast temperature and infant's crying have also been suggested to be related to oxytocin rise and to stimulate the let-down reflex (Uvnas-Moberg and Eriksson 1996).

It has also been found that early skin-to-skin contact has a long-term effect and seems to promote the infant's ability to handle stress even 1 year after birth (Bystrova, Ivanova et al. 2009).

### 1.2.2 The newborn's prefeeding and breastfeeding behaviour

Early mother-infant skin-to-skin contact induces a biological program (Widstrom, Ransjo-Arvidson et al. 1987; Nissen, Lilja et al. 1995) that facilitates breastfeeding (Matthiesen, Ransjo-Arvidson et al. 2001) and bonding (Klaus, Jerauld et al. 1972; Uvnas-Moberg 1996).

The healthy newborn put in skin-to-skin contact on its mother's chest, performs an inborn prefeeding behavior to find the breast and start to breastfeed (Widstrom, Ransjo-Arvidson et al. 1987). At about 15-20 minutes of age the newborn performs a sort of breast massaging movements with its hands which result in maternal oxytocin release (Matthiesen, Ransjo-Arvidson et al. 2001). When the infant starts seeking the breast, the rooting reflex becomes successively more mature and distinct. During a mature rooting reflex, the mouth is wide open and the infant is ready to attach to the breast. At the same time, the tongue is positioned in the bottom of the mouth to facilitate a grasp of the nipple/areola as the baby attaches to the breast with a forward movement with the head. Interestingly, prior to this rooting-tongue reflex (Widstrom and Thingstrom-Paulsson 1993), the baby makes licking movements, which are probably part of a program aimed at shaping the areola and nipple for easy attachment as well as to transmit taste from the

breast to the baby's mouth. This "familiarization" behaviour can take up to 15 minutes and occurs before the baby latches on the breast and has been identified as an essential step in the onset of sucking. During this period, gradually, the newborn coordinates eye-hand-breast-and-mouth movements, and at the same time, rooting and sucking behaviors occur (Widstrom, Lilja et al. 2011).

### 1.2.3 Parental interaction with the newborn and bonding

Tactile touch has been utilized as a marker of attachment (Grossmann 1981) and parental tactile contact with the newborn may assist in eliciting feelings of love for the newborn infant and enhance parental sensitivity and responsiveness to their infant's cues. Bonding has been referred to the emotional ties from parents to the infant and can be defined as a unique relationship between two people that is specific and endures through time (Kennell and Klaus 1998). For example prolonged eye contact, kissing and tactile touching has been behaviour characteristics for bonding.

#### *Mothers*

In mothers not exposed to analgesia, the short-term effect of early suckling and touch of the nipple after birth has previously been found to have particular significance for the ties between the mother and the newborn infant. It has been found to influence maternal sensitivity, as measured by the time mothers spend with their infant soon after birth and to increase maternal communication to newborns post partum (Widstrom, Wahlberg et al. 1990). Previous studies have shown that mothers benefit to have the baby in close contact. Mothers who have had their babies around the clock experience closeness to the baby as very natural and satisfying (Svensson, Matthiesen et al. 2005).

#### *Fathers*

Today it is crucial for new parents to become a family and get mutually involved in the care and responsibilities of their newborn from the very beginning. During the transition period it is of utmost importance to provide social support in the development of the new roles as parents (Fredriksson, Hogberg et al. 2003). It has been shown that fathers who have had skin-to-skin contact with their newborn, premature infants by kangaroo care felt calm and tranquil and felt satisfied since they could offer similar care as the mothers (Tessier, Cristo et al. 1998). The fathers' presence after delivery in primiparas has been

found to positively influence the mothers breastfeeding duration, which might indicate the importance for the parents to support each other during the new parental experience at birth and post partum (Ekstrom, Widstrom et al. 2003).

After a Caesarean birth, fathers could make a definite contribution to care for the infant if the mother is not available (Erlandsson, Dsilna et al. 2007) and fathers who have skin-to-skin contact with their newborn after birth reduce the infants' crying (Erlandsson, Christensson et al. 2008).

### *Infants*

Recent findings from neuro-psycho-biological studies show that early interaction also has effects on growth and the organization of the maturing brain, affecting both physiological and psychological development (Gunnar 1998; Schore 2000)

According to Trevarthen, the exchange of verbal and nonverbal information between the mother and the baby, the early reciprocity and turn-taking, is a primitive form of exchange of information and feelings, which forms the basis for the capacity in later life to attune communication to feelings of different kinds (Trevarthen and Aitken 2001).

Studies indicate that early interaction leads to mutual adjustments of communication between infants and adults (Hedenbro, Shapiro et al. 2006).

The maternal talking while breastfeeding corresponds well with the newborn's sophisticated ability to perceive the mother's voice and the fact that the human voice seems to have an organizing effect on the developing brain (Fifer and Moon 1994).

It has been shown that early sensory stimulation to organize complex brain networks is unbelievably great. Visual stimulation for the newborn baby one hour old, turns on the development of visual capacity (Sireteanu 1999); gentle touch/stroking and other discrete stimuli seem to support neuro-developmental processes (Field, Schanberg et al. 1986; Als, Duffy et al. 1996).

However, the infants early behaviour is easily disturbed by ward practices such as gastric suction of the newborn (Widstrom, Ransjo-Arvidson et al. 1987), infant-parent separation (Christensson, Cabrera et al. 1995), opiates given to the mother (Nissen, Widstrom et al. 1997), epidural anaesthesia during labour (Ransjo-Arvidson, Matthiesen et al. 2001) or application of eye treatment to the infant that disturbers the first eye-to-eye contact and infant-parent interaction (Wahlberg 1982).

### *Sex differences*

Already at birth there might be sex differences in behavior as the brain is influenced by sex hormones during fetal development leading to sex differences in the structure of the brain, and thus behavior (Bell and Costello 1964; Hines 2010; Berenbaum and Beltz 2011). Differences in sex related reaction patterns may also be seen in adults (Eidelman, Hovars et al. 1994; Cohen-Bendahan, van de Beek et al. 2005).

#### 1.2.4 **Physiology of oxytocin**

Behind many maternal adaptations, a number of physiological alterations can be found which may be due to oxytocin released in the brain as well as into the circulation. For a better understanding of the findings in this thesis, the hormone oxytocin and its putative effects on behavior are described.

Oxytocin is synthesized in the supraoptic (SON) and paraventricular (PVN) nuclei of the hypothalamus. Oxytocin is emitted by the magnocellular neurons in the SON and PVN, to the posterior pituitary from where it is released into the circulation to exert its hormonal effects. Once in the circulation oxytocin has a half-life of one to two minutes (Richard 1991; Ludwig and Leng 2006).

Oxytocinergic nerve fibers originating from the parvocellular neurons in the PVN reach a number of different areas in the central nervous system (CNS) where oxytocin can exert neurogenic effects. Oxytocin is secreted into various regions in the brain and into the peripheral circulation. The areas of the brain which are reached by the oxytocin neurons are among others, the limbic system including the amygdala, which is linked to the control of social interaction and emotions (Buijs, De Vries et al. 1985). In the CNS oxytocin has a prolonged half-life of about 20 minutes compared to its half-life in the circulation (Richard 1991; Stancampiano, Melis et al. 1991; Burbach, Young et al. 2006; Ludwig and Leng 2006). Oxytocin is transported via the neurohypophysis into the circulation to reach the target organs such as the uterus and mammary glands, where it acts at specific oxytocin receptors (Leng, Meddle et al. 2008).

Oxytocin increases in response to sensory stimulation during pregnancy, parturition, suckling and feeding in both males and females (Burbach, Young et al. 2006). In addition, physical warmth, massage-like stroking, and olfactory cues can also induce the release of oxytocin (Stock 1988; Uvnas-Moberg, Bruzelius et al. 1993; Agren 1995; Uvnas-Moberg 1998; Lund 2002).

Parallel release of oxytocin into both the brain and the circulation has been shown during vaginocervical stimulation, parturition, suckling, feeding and in mammals

(Kendrick, Keverne et al. 1986; Kendrick, Keverne et al. 1988; Hattori, Morris et al. 1990; Keverne and Kendrick 1994; Leng, Meddle et al. 2008). During such intense stimulation of oxytocin release, the oxytocin system in the PVN and SON undergo morphological and functional changes. The neurons become closer to each other, allowing interaction between these cells. Further, the neurons start to burst in synchrony, causing a pulsatile release of oxytocin into the circulation (Hatton and Tweedle 1982; Theodosis, Chapman et al. 1986; Theodosis 2002). During labour the frequency of pulses increases and during the second stage of labour the frequency can reach 6 pulses per 10 minutes (Fuchs, Romero et al. 1991)

### *Behavioral effects of oxytocin*

In mammals, oxytocin is known to play a role in maternal bonding. In animal models endogenous oxytocin has been shown to be released into the brain to activate physiological and behavioral adaptations in the mother (Keverne and Kendrick 1994; Kendrick 2000; Poindron 2005).

During a vaginal labour, endogenous oxytocin is released into the brain to activate physiological and behavioural adaptations in the mother (Fuchs, Romero et al. 1991; Poindron 2005). It has previously been suggested that the onset of maternal behaviour is promoted during delivery, through the fetus' stimulation of the birth canal, transmitting impulses via the pelvic nerve to reach the PVN (Ferguson 1941).

Indeed, intracerebral oxytocin injection has been found to be essential to induce maternal behaviour in inexperienced ewes with a peridural anaesthesia (Levy, Kendrick et al. 1992). Oxytocin has also been demonstrated to enhance social interaction in many types of mammals and to increase vocal communication, for example, in pigs and rats (Hofer 1996; Algers and Uvnas-Moberg 2007).

As in animals it is likely that neuroendocrine hormonal changes take place in the human brain to enhance bonding and parental behavior to strengthen the ability to take care of a newborn infant. Studies in both animals and humans support the concept of a sensitive period, very soon after delivery, during which a strong mothering bond is formed.

In human mothers, oxytocin may play a similar role as in mammalian mothers (Uvnas-Moberg, Johansson et al. 2001). In a previous study, it was found that unmedicated mothers showed a long lasting elevation of oxytocin for the first 45 minutes after vaginal birth when being in skin-to-skin contact with their infant (Nissen, Lilja et al. 1995). The

results suggested that the high levels of oxytocin coincide with a putative sensitive period immediately after birth (Nissen, Lilja et al. 1995)

Oxytocin is known to enhance uterine contractions during labour to facilitate vaginal birth and to contract the uterus after birth of the infant to prevent bleeding (Fuchs, Fuchs et al. 1984; Fuchs, Romero et al. 1991). Oxytocin is also well known to be associated with lactation and the let-down reflex (Newton and Newton 1948; Lincoln and Paisley 1982). During skin-to-skin contact oxytocin is released and may facilitate several aspects of the interaction between mother and child (Uvnas-Moberg 1996) and mood regulation (Uvnas-Moberg, Bjokstrand et al. 1999).

It has also been found that oxytocin increases social interaction (Hollander, Bartz et al. 2007), and increases the ability to interpret the emotional valence of facial expressions (Domes, Heinrichs et al. 2007) and of the voice (Domes, Heinrichs et al. 2004; Domes, Heinrichs et al. 2007).

In human fathers, very little is known about paternal oxytocin release. Oxytocin release has only been studied in connection with sexual functioning (Ogawa, Kudo et al. 1980), in connection with recognition of a face (Lischke, Berger et al.), trustful behavior (Kosfeld, Heinrichs et al. 2005), and to reduce stress in men (Heinrichs, Baumgartner et al. 2003).

As with primate mothers, fathers' interaction with the young probably involve habituating to them, recognizing their various cues, and developing more behavioral interaction skills.

### 1.2.5 **Caesarean section**

Over the last few decades, the techniques of caesarean section have improved and it is usually performed under an anaesthetic blockade, either a spinal block or an epidural block which allows the mother to stay awake during the surgery. In connection with caesarean birth, oxytocin is routinely given in doses of 5 IU (4.15 micrograms) to prevent postpartum bleeding. Often higher doses of oxytocin are administered as infusion if there is any tendency of more profuse bleeding.

#### *Adverse effects*

Evidence of acute maternal side-effects of administration of oxytocin can be observed as vomiting and elevation of blood pressure (Dyer, Butwick et al. 2011).

External oxytocin also induces a desensitization of the myometrial oxytocin receptors during prolonged or repeated stimulation during labour (Phaneuf, Rodriguez Linares et al. 2000) (Liedman, Hansson et al. 2009).

Different interventions during birth may also reduce levels of oxytocin release in the long-term. Previously, a dose dependent negative relationship was observed between the amount of oxytocin administered to the mother during labour and the oxytocin levels in connection with a breastfeeding two days after birth (Jonas W 2009).

Giving birth by caesarean section may result in reduced activation of physiological and behavior adaptations. Delayed onset of maternal adaptation has been observed both after emergency caesarean section (Nissen, Uvnas-Moberg et al. 1996; Nissen, Gustavsson et al. 1998) and after normal vaginal birth with epidural anesthesia (Jonas, Nissen et al. 2008).

The reason for this is not known, but the absence of labour, anesthetic block, the stress of surgery and the interruption of the biological birthing process may all contribute to this difference.

#### **1.2.6 Breast feeding and latch-on problems**

Breastfeeding is the ideal nutrition for the newborn with numerous components supporting healthy growth and development (Horta BL 2007; Ip, Chung et al. 2007; Agostoni, Braegger et al. 2009). A number of illnesses and infections have been found to be lower in incidence and less severe in breastfed infants. These include diarrhea, respiratory tract infection, otitis media, atopic eczema, asthma (young children), obesity, diabetes type 1 and 2, childhood leukemia and sudden death syndrome (Ip, Chung et al. 2007). The health benefits for the mother include child spacing (Peterson, Perez-Escamilla et al. 2000), lower risk for developing type 2 diabetes as well as for developing breast and ovarian cancer (Ip, Chung et al. 2009).

Human newborns' pre-programmed biological behaviour to approach the breast and start suckling by its own capacity is essential for survival and is similar to other mammals. In mother-infant dyads suckling is initiated by skin-to-skin contact within the first two hours after birth.

After some interventions, especially after a complicated birth, skin-to-skin contact is not established resulting in delayed first breastfeeding. Among the interventions known to hamper exclusive breastfeeding are caesarean section, anesthetic blocks (Ransjo-

Arvidson, Matthiesen et al. 2001; Rowe-Murray and Fisher 2002; Beilin, Bodian et al. 2005; Wiklund, Norman et al. 2009), unnecessary post partum separation (Winikoff, Laukaran et al. 1986), and delayed first suckling (Chapman and Perez-Escamilla 1999; DiGirolamo, Grummer-Strawn et al. 2001; Ekstrom, Widstrom et al. 2003; DiGirolamo, Grummer-Strawn et al. 2008). In addition, breast milk supplementation given to the infant without medical reason delays initiation and duration of breastfeeding (Dewey, Nommsen-Rivers et al. 2003; Ekstrom, Widstrom et al. 2003; Gagnon, Leduc et al. 2005); and if breast milk supplementation is given by bottle instead of a cup to dyads requiring multiple supplements (Howard, Howard et al. 2003), this practice is also known to hamper exclusive breastfeeding.

Thus, infants with latch-on problems during the first months after birth are a common cause of parental and staff stress and may lead to early termination of breastfeeding (Dewey, Nommsen-Rivers et al. 2003; Scott, Binns et al. 2006; Santo, de Oliveira et al. 2007; Lamontagne, Hamelin et al. 2008).

Typical hospital staff practices that include trying to attach the infant to the breast with a grip around the infant's neck and a grip around the mother's breast/nipple ("hands-on latch intervention") have earlier been suggested to cause an inhibition of the baby's inborn rooting-tongue reflex. Further, if this practice is too robust and intrusive the baby may scream and show an adverse behavior to the breast, fighting to avoid the breast instead of breastfeeding (Widstrom and Thingstrom-Paulsson 1993). Weimers et al. (Weimers, Svensson et al. 2006) described mothers' negative feelings about this practice; many have experienced the "hands-on latch intervention" as unexpected and heavy-handed touching of the breasts when trying to attach the infant. This kind of forceful help could be an underlying factor for infant latch-on problems.

### 1.2.7 **Statement of the problem paper I-IV**

To our knowledge, no studies have been performed to compare interaction of mothers and fathers with and without skin-to-skin contact with the newborn infant immediately following a planned Caesarean section. Possible effects of oxytocin release during skin-to-skin contact in mothers and fathers immediately after cesarean section have not been studied. However, no studies have indicated that oxytocin is released in men in connection with the birth of the child, describing the father's immediate behavior if they get to have the baby skin to skin immediately after birth or if it promotes an early fatherly behavior.

Considering the increased use of Caesarean Section, studies providing a deeper understanding of infant-parent interaction immediately following a planned Caesarean section and parental adaptation will contribute to developing guidelines for care in connection with Caesarean section.

“Older” infants with latch-on problems have not been studied previously with respect to the intervention of skin-to-skin contact with the mother. Skin-to-skin contact as a method to restore the pre-programmed biological behaviour to attach to the breast and start sucking has not been studied.

## 2 AIMS

**The overall aim** of this thesis was to investigate the impact of early skin-to-skin contact on maternal, paternal and infant interaction immediately after Cesarean section and to study the effect of skin-to-skin contact on severe latch-on breastfeeding problems after birth.

The specific aims are:

- To explore the vocal interaction between parents and newborns after a planned caesarean section during the immediate postpartum period, the differences in vocal communication that occur when the newborn is in skin-to-skin contact with the father or the mother; and possible differences in parental vocalization when the newborn is and is not in skin-to-skin contact **(I)**.
- To investigate the breast-seeking and crying behaviours of newborn girls and newborn boys, in skin-to-skin contact with their mother or their father after a planned caesarean section; the mothers' and fathers' interactive behaviours with their newborn girl or boy; and the time-point for the first breastfeeding event, for girls and boys, after having been in skin-to-skin contact with their mother or their father **(II)**.
- To examine the oxytocin release pattern from birth until two hours post partum in mothers with or without skin-to-skin contact after birth with a planned caesarean section and in fathers with or without skin-to-skin contact after birth with an elective caesarean section; and to study the personality profile in mothers two days after childbirth with or without skin-to-skin contact **(III)**.
- To investigate if placing an “older” infant with severe latch-on problems in skin-to-skin contact with the mother would positively affect the infant's ability to latch-on when compared to infants who did not have skin-to-skin contact but were held clothed in the mother's arms in a common breastfeeding position; and to compare the proportions of infants latching-on, the length of time until regular latching-on was achieved, and the maternal emotions before and during breastfeeding sessions **(IV)**.

### **3 MATERIAL AND METHODS**

This doctoral thesis is based on two different research programs; papers **I-III** are based on research program one and was collected at Danderyds hospital (1997-2001), and paper **IV** is based on research program two and was collected both at Danderyds hospital and at Karolinska University hospital (1998-2004).

#### **3.1 SETTING (I-IV)**

At the time of the data collection both hospitals had approximately 5000 deliveries per year. In Sweden the caesarean section rate had increased from 10% 1991 to 16% 2004 (National Health and Welfare 2011). The number of elective and emergency caesarean sections remained equally distributed through-out these years.

In Stockholm the frequency of epidural during vaginal delivery was 19% in 1997 and increased over the years up to 34 % in 2004. Epidural was more common among primiparas and was in 1997 27% at Danderyds hospital and 40% at Karolinska University hospital. Common anesthetics for caesarean section were spinal or epidural analgesia.

At both Danderyds hospital and the Karolinska University hospital in Solna the healthy newborn infants were routinely put skin-to-skin on their mother's chest immediately after a vaginal birth. After a Caesarean section, skin-to-skin contact was not yet a routine. Mother-infant separation after Caesarean birth was still practiced, but was questioned.

The maternity practices post partum included day and night rooming-in, breastfeeding on demand, father involvement during labor and at the maternity ward. In Sweden all maternity hospitals had been officially designated to practice the "Baby Friendly Initiative" according to the ten steps to successful breastfeeding (WHO 1989).

Early discharge had begun at this time, so the mothers with normal vaginal deliveries, and healthy infants left the hospital within 72 hours, except for women with caesarean section who were discharged after approximately five days.

The breastfeeding rate over the study period (1997-2004) was high. Approximately 98% of all newborns initiated breastfeeding the first week post partum. The exclusive breastfeeding rates at 4 months during 1997-2004 decreased from 69 to 64 % while partly breastfeeding increased from 15% to 19% (National Board of Health and Welfare 2010).

In paper I-III, skin-to-skin contact with either mother or father following an elective cesarean section was studied. In the second research program skin-to-skin contact was used as an intervention to latch-on problems in infants from 0-4 months of age.

The procedures for paper I-III and for paper IV are presented separately in order to facilitate the understanding of the study specific procedures, including sample selection, inclusion criteria and drop outs.

### 3.1.1 Study overview

**Table 1.** Overview samples, design, data collection, instrument and statistical analysis.

Study	Design	Patient sample	Type of data	Statistical analysis
<b>Paper I</b> Data collected 1997-2001	Randomized controlled trial	37 mother 35 fathers and their 37 newborn infants	Video- observations at birth, 0-30 minutes post partum	Means 95% CI Student t-test for independent groups Analysis of variance (ANOVA) repeated measures, Fischer's exact test
<b>Paper II</b> Data collected 1997-2001	Randomized controlled trial	37 mothers 35 fathers and their newborn infants, 20 girls and 17 boys	Video- observations at birth, 0-30 minutes post partum and Point-in-time of first breastfeeding appearance	Means 95% CI Student t-test for independent groups, linear regression, Spearman rank correlation, Mann Whitney U-test for independent samples, Kolmogorov- Smirnov test
<b>Paper III</b> Data collected 1997-2001	Randomized controlled trial	34 mothers 31 fathers and their 34 newborn infants	Plasma oxytocin - 5 minutes-120 minutes post partum Mothers KSP 2 days post partum	Means 95% CI Mixed Linear model, Student's <i>t</i> -test for independent groups and Student's <i>t</i> -test for paired groups Fischer's exact test
<b>Paper IV</b> Data collected 1998-2004	Randomized controlled trial	103 mother-infant pairs	Psychological aspects Breastfeeding (BF) sessions, Interviews and breastfeeding scales	Chi-square, Fischer's exact test, Mann Whitney U test, Simple regression analysis

## **3.2 DATA COLLECTION AND METHODS**

Data collection instruments for the four studies were selected to answer questions related to parent-infant skin-to-skin contact. The data collection methods illustrate a methodological approach to capture the parental behavior at birth and the newborns inborn biological prefeeding behavior at birth and beyond.

## **3.3 PAPER I-III**

### **3.3.1 Recruitment of sample**

When the couples arrived at the maternity ward, they received information about the study and were invited to participate. If they were willing to participate, they were told that they would be informed about the group assignment the next morning, on the day of surgery.

#### *Inclusion criteria*

To be included in the study, the primiparae needed to have had a healthy, uncomplicated pregnancy and an elective caesarean section at term (38-42 gestational weeks). The woman could not have smoked during the third trimester. The baby needed to be healthy at birth, have had an Apgar score of at least 7, at the one-minute testing mark, and been immediately placed in skin-to-skin contact, after having been dried with a towel.

All women fulfilling the inclusion criteria were consecutively recruited at the maternity ward the day before surgery. The only inclusion criterion for fathers was that they were willing to participate in the study.

#### *Randomization*

Information about the treatment was placed into an opaque envelope marked with an identity number, prepared by a person who was not directly involved in collecting research data for this study.

On the day of surgery, the project leader opened the envelope with the inclusion number corresponding to the consecutive order of the couple and informed them whether the mother or the father should have the baby in skin-to-skin contact during the intervention.

The inclusion was done as late as possible to avoid unnecessary drop outs due to unexpected emergency cesarean sections. After an emergency cesarean section, the protocol designed for

the study could not be applied and the couple would no longer be eligible to participate in this study.

All 42 newborns were randomized to skin-to-skin-contact with either their mother (SSCM) or their father (SSCF), for the first 5-30 minute period after birth. Thus, all infants were in skin-to-skin contact with either the mother or the father, after an initial 5 minutes of skin-to-skin contact with the mother after birth, see flowchart of the study design in Figure 1. The parent not randomized to skin-to-skin contact served as the control: control fathers group (CONF) and control mothers group (CONM). All parents consented to participate.

### 3.3.2 Procedure

The local procedure mandated that women who were prescribed a cesarean section were required to take a shower and scrub the entire body, including the breasts, with chlorhexidine the day before and the day of the surgery. All women fasted from midnight before the surgery. At around 08:00 AM a glucose intravenous infusion was provided, with the surgery taking place approximately 1 hour later.

The father was dressed in a patient shirt with buttons at the front to make it easy for him to have skin-to-skin contact with the newborn and he received an intracubital catheter in his arm for blood sampling.

The mother was dressed in a patient shirt, easy to remove during surgery, to make it possible to have skin-to-skin contact with the newborn immediately at birth. All women received a spinal block with 12.5 mg of high-density bupivacaine and 10 ug fentanyl for anesthesia. Additional drugs were used to regulate blood pressure, when needed.

Immediately after birth the baby was dried, covered with a towel, and placed transverse, with the head to the right, in skin-to-skin contact on the mother's chest with the nipple accessible. This position also allowed surgery to continue. Oral suctioning of mucus from the mouth was not necessary in most cases.

In each case, the infant's body was covered with warm towels to maintain the newborn in a stable temperature and the ambient temperature in the theater was 20°C. The parents were instructed to act naturally and spontaneously. All infants stayed with their mothers for 5 minutes. Thereafter, the baby either stayed in skin-to-skin contact with his/her mother or was placed in skin-to-skin contact on his/her father's chest for the next 25 minutes, according to the outcome of randomization.

In cases when the baby was put on the father's chest, the baby could turn his/her upper body and its eyes were leveling the nipples of the father. The father sat comfortably, leaning back in an armchair, beside the head-end of the operating table, so the parents could have eye contact and freely communicate and touch each other and the infant. The parents were encouraged to interact with each other and the baby. The parents and the staff were informed that we would explore the newborns' natural behavior when placed in skin-to-skin contact with either parent. The approach of the staff in the operating theater was gentle, kind and supportive towards the parents.

After 30 minutes had passed, all the babies were kept in skin-to-skin contact with the mother for the duration of the allotted 90-minute maximum time frame. Thereafter, the infant was removed from the mother's chest and underwent routine examination, performed by a midwife. Then, the infant was dressed and returned to his/her parents.

#### *Administration of oxytocin post partum*

All mothers received 4.15µg (5 IU) oxytocin (Syntocinon®; Novartis AB, Täby, Sweden) intravenously, after collection of the first blood sample at birth (0 minutes). The staff was asked not to give additional oxytocin if not urgently needed. Additional administration of oxytocin infusion (Sodium chloride 500 ml) with 41.5 µg (50IU) oxytocin occurred in a 19 mothers (Table 5). The mean duration of the infusion time was 114 minutes (95%CI 79.42-149.40), i.e. approximately 0.36 µg oxytocin (0.43IU) per minute. There was a significant difference in the duration of the infusion time between the groups; the mean difference was 68 minutes (95%CI 1.66-134). The infusion time in the control mothers was significantly shorter, mean 91 minutes (95%CI 53.22-127.69) versus mean 158 minutes in the skin-to-skin contact mothers (95%CI 83-233.25) (p=0.45).

### **3.3.3 Data collection**

#### *Video tape recording (I-II)*

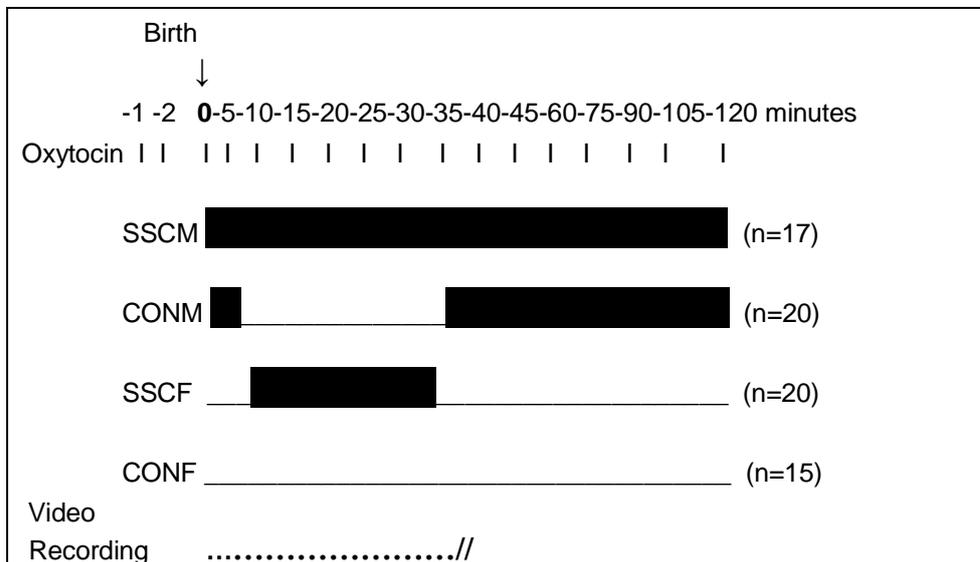
Data were collected by means of video and sound recording by placing a video camera 1.5 meters away from the infant, with the lens focusing on the upper part of the baby and the parent in skin-to-skin contact, the parent without skin-to-skin contact was also visible on the videotape. The video recording began immediately at birth and continued for up to 30 minutes (paper I-II), (Figure 1).

*Blood sampling for plasma oxytocin (III)*

The mother had a cannula inserted in her cubital vein before the anesthetic block was administered and the father had a cannula inserted at least 15 minutes before the surgery started. Blood-samples were collected in previously prepared ice-chilled tubes containing Trasylol® 10 000 IU/ ml plasma and Heparin® 5 000 IU/ml plasma. Each sample contained approximately 5 ml blood. In total 16 blood-samples were collected from each parent at the same time intervals. The first blood sample (basal) was taken at approximately 5 minutes before surgery. At birth (0 minutes post partum) the second blood-sample was taken and thereafter blood-samples were collected every five minutes for the first 45 minutes and then every 15 minutes up to two hours (Figure 1).

*Treatment of blood samples*

After the blood samples were centrifuged at +4° C, the plasma was taken off and the samples were stored at -20° C until they were analyzed.



**Figure 1.** The filled line indicate skin-to-skin contact and SSCM=skin-to-skin contact mothers; CONM=control mothers; SSCF= skin-to-skin contact fathers; CONF=control fathers.

*3.3.3.1 Hospital birth records (I - III)*

Obstetric background data was collected from the hospital birth records. The point-in-time for the first breastfeeding was noted.

### 3.3.3.2 Assessment of personality profile in mothers (III)

The women filled in the Karolinska Scale of Personality (KSP) on the second day post partum. KSP has been developed by Schalling and co-workers (af Klinteberg 1986). It consists of 135 items with a four-point response format ranging from 1 “agree completely” to 4 “do not agree at all”. The items explicitly refer to habitual behavior or feelings and have been grouped into 15 dimensions clustered into four main groups measuring different aspects of personality.

The *Anxiety-proneness scales* consist of five sub-scales: somatic anxiety (autonomous disturbances such as heart beating, sweating), psychic anxiety (worrying and feeling socially insecure), muscular tension (difficulties in relaxing), inhibition of aggression (being unable to speak up for oneself), and the psychasthenia scale (low mental energy and difficulties in recovering from stress).

The *Extroversion related scales* include three sub-scales; impulsivity (non-planning and acting upon the spur of the moment), monotony avoidance (avoiding routine and seeking excitement) and detachment (need for distance in interpersonal relations). The two *Socialization scales* measure socialization (positive childhood experiences and satisfaction with present life) and social desirability (socially conforming). The five *Aggression-hostility related scales* measure indirect aggression (slamming doors), verbal aggression (shouting and arguing, being overcritical), irritability (proneness to anger, lack of patience), suspicion (feelings of distrust, projecting hostility to others) and guilt (feeling remorseful or ashamed).

High scores on all scales indicate more problems, except for the socialization and social desirability scales, where high scores indicate fewer problems. The KSP sub-scales were transformed into T-scores to enable comparison of the results of the present study with a normative group of women with a mean score of each sub-scale of 50 and a standard deviation is 10, standardized for age and sex. Mean scores deviating more than +/-5 from the normative group and with a  $SD \leq 10$  were considered to be significant ( $p \leq 0.05$ ). The scale has been tested extensively, is well established in Sweden, and has high validity, test-retest stability and internal consistency (af Klinteberg 1986; Gustavsson 1997).

### 3.4 PAPER IV

#### 3.4.1 Recruitment of sample

Two investigators who were experienced practicing midwives and specialists in breastfeeding, collected data, one of which did from two hospitals. Before and during the recruitment period the staff at the maternity wards at the two hospitals, well baby clinics and breastfeeding out-patient clinics were informed about the study. A poster information sheet was also put on the walls in the maternity and well baby clinic. The staff informed mothers who had infants with latch-on problems about the study and the mothers themselves contacted the investigator if they wanted to participate in the study.

##### *Inclusion criteria*

Healthy mothers who wanted to breastfeed and but had healthy infants with a severe latch-on problem were offered to participate in the study. The severity of the latch-on problem was reported by the mother.

A latch-on problem was considered when the infant 1) did not latch-on at all or, 2) had started to latch-on on but discontinued or had other serious problems catching the nipple and starting to sucking the breast such as 3) latched-on superficially without or with a nipple shield or 4) latched-on only to one breast.

#### 3.4.2 Procedure

In total 230 mother-infant dyads with latch-on problems contacted the investigators for participation in the study. An appointment was made for mother-infant pairs to meet the investigator collecting data at the hospital where the infant was born. The meeting took place in a private room equipped with a bed, an armchair and a table.

##### *A professional standardized model to guide mothers*

During all procedures the comfort of the mothers and infants was a priority, so protocol for data collection took place only when the infant and mothers felt at ease. All through the interview and breastfeeding session, the performance was adapted to fit the mother and the infant's individual situation. Thus, there was some flexibility in the order of the data collection schema but generally these instruments were administered in the order described in Table 2.

The two investigators (KS and MV) developed a *professional standardized model* in order to use a common clinical approach to guide mothers with breastfeeding problems. Reliability

and consistency between the investigators and the information they gave was established. The model was applied during the interview and breastfeeding session and can briefly be described as follows: a) create a friendly and non-judging approach, b) show attentive interest to listen, c) support the women's self-esteem d) discuss the infant's signals e) reinforce positive breastfeeding behaviors, f) give knowledge based information. Furthermore, the approach precluded the midwives touching either the infant directly, or the mother's breasts. An outside reviewer found that there was reliability and consistency between the investigators. Regarding the consultation method it was found that the investigators treated the mothers in both groups equally, without favouring any of the groups. There was also a consistency regarding the consultation method the investigators used to support and reassure the mothers, and convey information about breastfeeding for both groups [20]. In Table 2 an overview of the data collection methods and the order of data collection are presented.

**Table 2.** Overview of methods and research procedure

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<b>First visit:</b>	Interview (approximately one hour)
	Breastfeeding Emotional Scale and Breastfeeding Pain Scale
	assessing feeling about breastfeeding in general (five minutes)
Screening	Screening breastfeeding session, including observation, assessment and consultation (approximately 30 minutes)
Intervention	Breastfeeding session after intervention, including observation, assessment and consultation (approximately 45 minutes)
	Breastfeeding Emotional Scale and Breastfeeding Pain Scale
	recalling feeling during breastfeeding session after intervention (five minutes)
<b>Visit after one week</b>	Support (varying times)
<b>Visit after four months</b>	Interview (approximately 30 minutes)
	Breastfeeding Emotional Scale and Breastfeeding Pain Scale (five minutes)
	Breastfeeding session (approximately 20 minutes)
	Breastfeeding Emotional Scale and Breastfeeding Pain Scale (five minutes).

### 3.4.3 Data collection

#### *Breastfeeding Emotional Scale*

The Breastfeeding Emotional Scale was developed in order to assess maternal feelings in relation to a breastfeeding. Mothers assessed their feelings regarding 12 emotions corresponding to a 7-point semantic differential scale with the following end points representing opposite values; “calm - stressed”, “unpleasant - pleasant”, “hopeful - hopelessness”, “fragile - strong”, “delight - sorrow”, “meaningful - meaningless”, “fearful - no fear”, “unconfident - confident”, “anger - harmony”, “demanding - undemanding”, “manageable - unmanageable” and “contented – frustrated”.

Some statements had the positive word on left side and others on the right side. Before the analyses the positive word was converted and coded as a high number and then all numbers were summarized for each mother. High numbers were interpreted as a positive emotional response. The face validity of the scale was tested by 14 mothers. It was found that the items of the scale were easily understood.

#### *Breastfeeding Physical Pain Scale*

The breastfeeding physical pain scale was a 7-point semantic differential scale with words representing the opposite values severe pain to no pain; High numbers were interpreted as more pain.

#### *Hospital records*

Health and additional socio-economic background data including marital status and obstetric data as well as data for infants were collected from the antenatal and hospital records.

#### *Screening for severe latch-on problems preceding randomization*

A semi-structured interview was conducted about current breastfeeding situation, routines at the hospital and socio-economic and obstetrical background variables. This interview usually lasted between 1-1 ½ hour depending of the infant’s behavior, which could indicate that the mother and infant needed a break.

To assess mothers' feelings about her breastfeeding, all mothers filled in Breastfeeding Emotional scale and Breastfeeding Physical Pain scale before the screening breastfeeding session began.

Mothers were asked to put the infants to the breast when suitable, and the investigators observed if the infant could latch-on on the breast and begin to suckle. During the breastfeeding session, attention was paid to physical impediments to establishing good suckling behaviours, such as mother's clothing, infant apparel or blankets. Then the mother's body position and how she positioned the infant in relation to the breast, eye contact with the infant as well as the infant's eye contact with the mother were noted. An observation protocol to identify infants with latch-on problems was developed. Each investigator tested the observation protocol on a selected number of mothers simultaneously and independently. The protocol was revised and retested until reliability was established.

During screening several types of infant latch-on on problems were observed and included such behaviours as no attempts at all to latch-on, failing to locate the breast, having the mouth wide open over the breast without attempting to latch-on, overactive rooting reflex over the breast, fending off the breast with their hands, or crying frenetically. Some infants looked like they wanted to avoid the breast, just fell asleep or did not move at all but remained in a "frozen" position. In 127 mothers the latch-on problem was resolved during the screening process and those mothers went happily home. The collected data from these mothers and infants was not analyzed but stored for later analysis. During the screening 103 mother-infant pairs were identified with a severe latch-on problem that was not resolved during the session.

#### *Randomization*

The 103 mother-infant pairs with severe latch-on problems were randomly assigned to either an experimental (n=53) or control group (n=50) as depicted in Figure 2. The randomisation was blocked for hospital (and thus investigator) as well as for time. In each of the two hospitals, mothers were assigned to either experimental or control group. Information was given in sealed opaque envelopes, which the investigators opened consecutively in the mothers' presence.

#### *Intervention*

When the infant seemed ready to feed, a breastfeeding session was performed according to the randomization of the mother-infant dyads to the experimental or control group.

*a) Experimental group*

The skin-to-skin intervention was performed in the following way. The mother was in a hospital bed in a reclined position and placed the infant prone between her breasts. The naked upper body of mother was in contact with the infant's naked body. The mother was encouraged to allow the baby to crawl while holding a protective arm lightly over the baby and having her arms supported by pillows. The mother was encouraged to talk and communicate with her infant if she liked. If the infant began to cry the mother was encouraged to comfort the infant. Once the infant was calm again, she was encouraged to return to skin-to-skin contact in a reclined position. In addition, mothers in the experimental group were recommended to use skin-to-skin as often as wanted when practicing breastfeeding at home. They were asked to document each time skin-to-skin was practiced.

*b) Control group*

In the control group, mothers and infants were fully dressed. The mother was usually positioned in the common breastfeeding position sitting in an armchair holding the infant in front of the exposed breast. She was advised to start breastfeeding as she usually did. If the mother felt more comfortable lying down she could do so. The mother was encouraged to allow the infant to move his/her head and arms freely. The mother's arms were supported with pillows. The mothers were encouraged to talk and communicate with her infant if she liked. If the infant began to cry the mother was encouraged to comfort the infant. Once the infant was calm again, she was encouraged to try breastfeeding again.

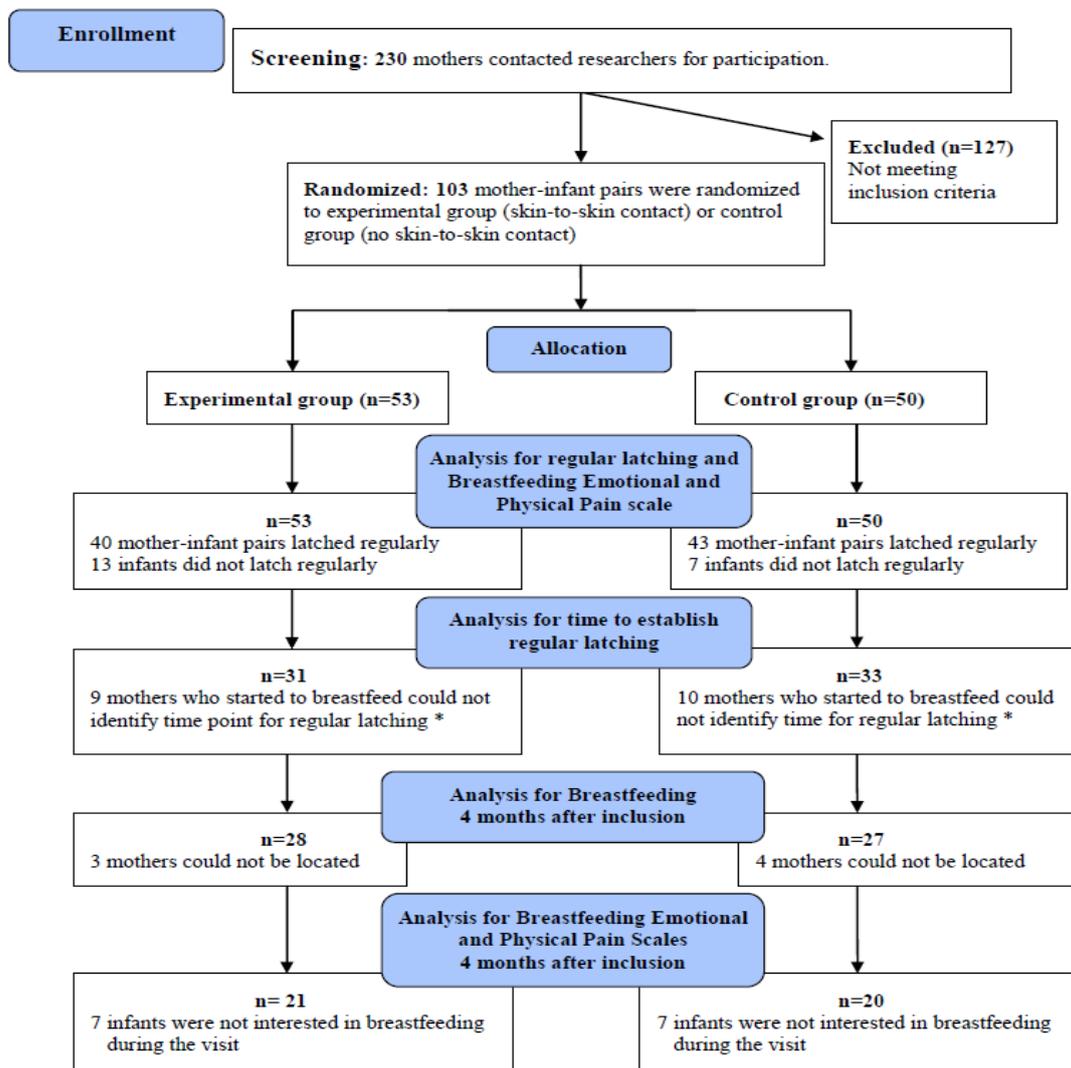
*c) Both groups*

Immediately after the intervention breastfeeding session, the mothers in both groups filled in the two scales on breastfeeding emotions and physical pain related to breastfeeding, recalling their feelings during this breastfeeding session. All mothers were instructed to apply the knowledge they had gained during this breastfeeding session when they returned home. Mothers were given two additional appointments with the investigator, the first scheduled one week out and the following visit and four months after inclusion. Both were held in the original setting.

*Breastfeeding follow-up interviews*

Mothers were asked relevant questions about her current feeding situation. During these interviews the investigators offered appropriate individual support if needed.

At four months, mothers still breastfeeding filled in the Breastfeeding Emotional Scale and the Breastfeeding Physical Pain Scale to evaluate their feelings before and during a breastfeeding session.



**Figure 2.** Flow diagram of progress (paper IV)

### 3.4.4 Data analysis

#### *Video analysis (I-II)*

##### *Phase I: Identification and definition of behaviors*

To define the *interactive behaviors* of interest, five videotapes were randomly selected and analyzed by the research team. The vocal interactions defined for the infant were crying, whining, and soliciting calls. The corresponding vocal interactions for the parents were soliciting sounds and speech directed to the infant and between the parents. The following

newborn behaviours were identified and were recorded the first time the behavior occurred: first time of strong rooting, first time of breast-massaging movements and first breastfeeding, The *interactive parental behaviors* coded were; finger-tipping touch, touching, smiling, kissing. The definition of all behaviours is defined in Table 3.

**Table 3.** Definition of interactive behaviors (paper I-II)

Variables	Definitions of variables
<b>INFANT BEHAVIOURS</b>	
Skin-to-skin-contact	The naked newborn infant is placed on his or her mother's or father's naked chest allowing contact with the nipple
Crying	Intense crying, difficult to stop with soothing care Dissatisfied and groaning sounds
Whining	Complaining sound
Silence	The infant is in a quiet state
Infant's soliciting calls	Short, contact-seeking, ringing sounds
First time of strong rooting	Breast-seeking behaviours, distinct head turning, and movements, sometimes followed by smacking sounds
First time of breast-massaging movements	The infant performs repeated breast-massaging movements
First breastfeeding	Appearance of the first latch-on and initiation of sucking the breast
<b>PARENTAL BEHAVIOURS</b>	
Mother's speech directed to father	Any verbal speech, but not soliciting sounds directed to the father
Mother's speech directed to infant	Any verbal speech, but not soliciting sounds directed to the infant
Father's speech directed to mother	Any verbal speech, but not soliciting sounds directed to the mother
Father's speech directed to infant	Any verbal speech, but not soliciting sounds directed to the infant
Mother's soliciting response	Short, contact-seeking, ringing sounds to the infant
Father's soliciting response	Short, contact-seeking, ringing sounds to the infant
Finger-tipping touch	Light touching with the fingertips on any part of the infant's body
Touch	Tactile touching and tapping hand movements on any part of the infant's body
Smiling	Mouth movements with retraction of lips comeasurements
Kissing	Touching the baby with the lips

*Phase II: Transcription of the videotaped behaviors.*

A coding protocol for transcription of the identified behaviours was developed. A person experienced in audio and visual detection scored all videotapes and sound tracks. The coder was blind to the specific experimental purpose. The transcription of the videotapes started from the moment when the newborn infant was approximately 1 minute old, and placed in skin-to-skin contact on the mother's chest. The videotapes were analyzed in real-time and then coded in 30-second observation periods. In all, 60 separate 30-second periods were analyzed. If a certain vocalization occurred during the 30-second interval observation, the vocalization was denoted as "1," and if it did not occur, it was denoted as "0." This type of transcription of videotapes has been described previously (Erickson 1982). The occurrence of the different types of behaviour during each 30-second interval was counted and then summarized into 5-minute intervals, in preparation for the statistical analysis.

If an observed behaviour was difficult to identify, a so-called, conference score of observed behaviors was developed between the four observers (Widstrom, Lilja et al. 2011). A 'conference score' was achieved among the observers by simultaneously studying the videos in real time and then summarizing the behaviors for each 30 second period. The tape was stopped while the notes were made but if the observers disagreed on the coding of a behaviour within the period, the tape was rewound and the sequence was restudied until the observers reached an agreement.

All behaviours observed during each 30 second period were monitored by an experienced observer who was not informed about the aims of this study. Data sheets for transcription was developed in excel and coded manually. The behaviors were listed in the vertical plane and the time in the horizontal plane for each observation.

During a few observation periods, technical reasons prevented certain behaviours from being visible. As a result, these were monitored as missing. These missing periods were equally distributed between participating infant boys and girls. This type of video transcription has been described previously (II).

*Phase III: Reliability test.*

Inter-observer reliability was estimated by allowing two independent observers to code four randomly selected videotapes. For every 30-second period, it was determined whether the two observers agreed or not. The frequency of agreement between them was then calculated for each variable. Inter-observer agreement ranged from 65 to 100 percent, mean 80% (Table 4).

**Table 4.** Inter-rater reliability test

<b>PARENTAL BEHAVIORS</b>	Mean ratio	<b>INFANT BEHAVIORS</b>	Mean ratio
Mother's speech directed to the father	71	Skin-to-skin-contact	100
Father's speech directed to the mother	72	Crying	77
Mother's speech directed to the infant	90	Whining	80
Father's speech directed to the infant	74	Silence	81
Mother's soliciting response	99	Infant's soliciting calls	76
Father's soliciting response	90	Breast-massaging movements	65
Finger-tipping touch	77	Strong rooting	92
Touching	77		
Smiling	80		
Kissing	99		

#### *Determination of oxytocin levels*

Oxytocin samples were analyzed by radio-immuno-assays (RIA). Oxytocin immunoreactivity was measured by RIA after prior purification of plasma with SEP-PAK C<sub>18</sub> cartridges (Water Assoc.Inc., Milford, PA, USA). The antibody KA<sub>19</sub> was used for the analysis (Milab, Malmö, Sweden). The cross-reactivity with arginine-vasopressin was 0.01%, with lysine-vasopressin <0.01% and with arginine-vasotocin 0.1%. The limit of detection of the assay was 2 pmol/ml and the intra- and interassay coefficients of variation were 10% and 13%, respectively (Stock and Uvnas-Moberg 1988).

#### 3.4.5 **Statistical analysis**

Nominal data were presented as proportions. Ordinal data were presented by median and quartiles (Q1, Q3) (paper II and IV). Interval data were presented by mean with 95% confidence intervals (CI) (paper I-III) and standard error (paper IV).

Spearman rank correlation was used to test the co-variation between the infants' soliciting and the soliciting of skin-to-skin contact fathers and mothers (paper I) and for calculating

correlations in behaviours with parents and infants (paper II). Fisher's exact test or Chi-square test was used to test the parents' response rate to infants' soliciting calls (I) and for differences between treatment groups (IV).

The following nonparametric tests were used: the Mann-Whitney U-test (paper II and paper IV), the Kruskal-Wallis test for independent samples, and the Kolmogorov-Smirnoff test (II). To test the sequence of events between the parents' first speech to the infant and the newborns' first soliciting calls (paper I) Student's *t*-test for paired samples was used. When single changes in paternal oxytocin levels were compared (III) Student's *t*-test for paired samples was also used (III-IV).

To test differences in behavior and over time between groups analysis of variance (ANOVA) was used (I-II).

The differences in timing of the first appearance of a specific behavior between infants in skin-to-skin contact with fathers or mothers were tested with Student *t*-test for independent groups (I). The same test was used to establish differences between the groups in the different subscales of KSP (III).

We used a mixed-effects model approach, since in the analyses of repeated observations for each individual the observations were correlated and varied with the time factors. The independent factors analyzed were: time, skin-to-skin contact or control, and oxytocin-infusion administered to the mothers. Separate analyses were performed for mothers and fathers. The variance-covariance for the model was assumed to be Compound Symmetry. First we used all independent factors in a multivariate model. Finally, we studied whether the effect of skin-to-skin contact and oxytocin-infusion differed; we tested the interaction between time, skin-to-skin contact and oxytocin-infusion. We used restricted maximum likelihood as our estimation method (III).

Simple regression analyses were used to study the relationships between the dependant variable time when regular latching and suckling occurred and the two independent variables infant's age at inclusion (IV) and the number of skin-to-skin events (only for treatment group).

In all papers  $p$ -value  $\leq 0.05$  was considered significant. For all calculations SPSS 17-20 (SPSS, Inc., Chicago, IL 2008 and 2011) have been used.

## 4 ETHICAL CONSIDERATIONS

The first research program was approved by the ethical committee at Karolinska Hospital, Stockholm, Sweden, dnr: 1995: 396. We were aware of that the method of our study, especially to take blood samples could disturb the parents during the Caesarean Section. The researchers were as careful as possible to not interfere when drawing blood samples. The parents were informed that they were free to withdraw the participation in the study at any time.

Informed written consent was obtained from parents and information was given both orally and written before enrollment.

All data were anonymously processed and coded. The parents and the staff were informed that we would explore the newborns' natural behavior when placed in skin-to-skin contact with either parent.

The common ward routine at the time when the study was performed was to separate the infant from its parents for at least two hours. The design of the study brought about an improvement for the parents and infant which was more in accordance with the guidelines for normal birth and Baby Friendly Hospital Initiative (I-III).

The second research program was approved by the ethical committee at Karolinska Hospital, Stockholm, Sweden, dnr: 1997-146. Mothers were verbally informed by the investigators about the study and signed a consent form including assurances about ethical issues such as anonymity, and that they were free to discontinue the study at any time (IV).

## 5 RESULTS

The following *case report* is a short introduction to the findings in paper I-II. The description illustrates the sequence of events in a video section and an attempt to bring to life the parent-infant interaction in skin-to-skin contact during the first 30 minutes after birth.

### **At birth mother-infant in skin-to-skin contact immediately after Caesarean Section**

*The infant is born, he takes the first breath and the birth cry follows.*

*He is immediately dried and put in skin-to-skin contact on his mothers' bare breast.*

*The father is sitting near the upper part of the mother; he holds his arm around her head and touches her gently.*

*Then he begins to touch the infants' upper body, first the arm, hand and head with his fingertips.*

*The father stands up and kisses the mothers head.*

*He examines the infant, gazing at his baby, he smiles.*

*The mother touches the infant with her fingertips, hand, arm and head.*

*The parents are softly talking with each other.*

### **Thereafter the newborn was transferred to have skin-to-skin contact with the father**

*After about five minutes, the infant is transferred to the father and he holds the infant in skin-to-skin contact on his bare chest.*

*The father looks at the infant; he is slowly moving in his chair to comfort the infant, he kisses the infant more than once.*

*The infant has stopped crying*

*The parents' talk and touch each other.*

*The father says that he believes that the infant is cold; he says that he is shivering a lot.*

*The staff answer that the infant looks fine.*

*The infant opens his eyes.*

*The infant touches the fathers' breast and takes his hand to his nose and mouth.*

*The environment in the operating theatre is noisy; the caesarean section operation is ending.*

*The father talks and the infant turns his head to the fathers face, studies his face, and initiates soliciting sounds within one second after the father had stopped talking.*

*The father smiles, and talks to the mother.*

*The infant looks at his father's face and expresses soliciting sounds.*

*The infant starts to make rooting movements on the fathers' chest.*

*After some minutes the father says*

*- "I believe he wants to breastfeed... he is trying to breastfeed".*

*The father smiles, looks at the baby and kisses him.*

## 5.1 PAPER I-III

Forty-two couples were asked to participate and the newborns were randomly assigned either to skin-to-skin contact with their mother or to skin-to-skin contact with their father.

### 5.1.1 Drop outs and exclusions

Two couples dropped out after randomization because the fathers changed their minds and did not want to participate in the study. Furthermore, one couple was excluded due to a low Apgar score in the infant. Two couples were excluded since they had not followed the randomization protocol because the mothers felt sick and no skin-to-skin contact was established. Two mothers in the skin-to-skin contact group turned out to be single on the day of surgery, yet maintained participation, since the randomization outcome allocated them to have skin-to-skin contact.

Thus, 37 first-time mothers and 35 fathers and their healthy full-term infants (mean gestational age, 38.5 weeks) participated in the study (I-II).

In paper III, four outliers were excluded, two fathers in the experimental group and two fathers in the control group. Further, two mothers, one in the skin-to-skin group and one in the control group, were excluded in the analysis as they received 83.0 µg (100 IU) oxytocin infusions and one mother in the skin-to-skin contact group received 4.15µg (5 IU) oxytocin intramural and these mothers were therefore not comparable and not included in the analysis. Thus, 34 mothers and 31 fathers were included in the analysis. Among the mothers included in the analysis, n=15 were randomized to have skin-to-skin contact, and n=19 were randomized to be controls.

Among the fathers included in the analysis, n=18 were randomized to have skin-to-skin contact and n=13 were randomized to be controls (III).

The mean age in the skin-to-skin contact fathers was 33.84 years (95% CI 30.72-36.97) and the corresponding age for the control fathers was a mean of 33 years (95% CI 30.32-35.56). The mean age in the skin-to-skin contact mothers group was 31 years (95% CI 28.41-33.84) and the corresponding age for the control mothers group was a mean of 32 years (95% CI 29.58-34.10). All couples were either cohabiting or married, except for two single mothers in the skin-to-skin-contact mothers group. Obstetric background data are reported in Table 5a. The infants' gestational age, Apgar score, and birth weight are reported in Table 5b.

**Table 5.** Obstetric data, presented as Mean and 95% Confidence interval

<b>a) Obstetric data</b>		<i>Control Mothers (n= 20)</i>	<i>SSC Mothers (n=17)</i>
Indication for Caesarean section			
Breech position	12		12
Pelvic/fetal skull disproportion	1		1
Humanitarian indication	3		3
Obstructed labor	2		0
Pelvis / column trauma	1		1
Post maturity	1		0
<i>Medication</i>			
Oxytocin 5 IU iv	20		17
Oxytocin 5IU intramurally	0		1
Oxytocin infusion 50 IU	12		7
Oxytocin infusion 100 IU	1		1
Bupivacaine mg	11.882 (11.072-12.693)		11.775 (10.789-12.761)
Fentanyl µg	15 (4.39-26.79)		10.33 (9.62-11.05)
Ephedrine mg	25.88 (19.07-32.70)		26.67 (14.12-39.21)
Morphine mg	0.1		0
Bleeding p.p. ml	805 (607.91-1002.09)		955 (698.18-1213.58)
<b>b) Infant data</b>			
		<i>Control Mothers (n= 20)</i>	<i>SSC Mothers (n=17)</i>
Gestational age		38.670 (38.127-39.213)	38.859 (38.521-39.196)
Apgar score 1 min 7/8/9/10	1/1/16/2		2/0/12/3
5 min 9/10	1/19		0/17
10 min 10	20		17
Oral suction	1		2
Birth weight (g)		3512.25 (3287.67-3736.83)	3526.47 (3316.88-3736.07)
Sex boys/girls		11/9	6/11

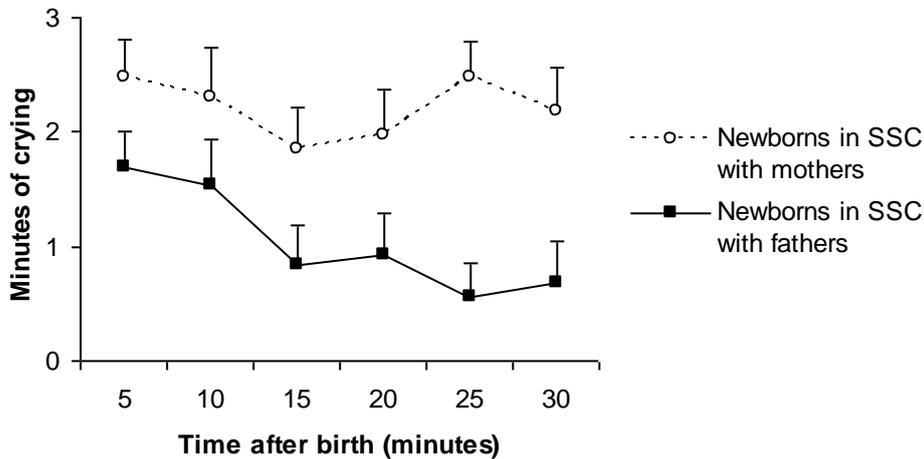
### 5.1.2 Crying behaviours of newborn girls and boys.

At birth, all infants started to breath and cry, and the so-called birth cry occurred for a mean of 1.19 minutes. The newborn was immediately put in skin-to-skin contact with the mother for 5 minutes, and the parents started to interact, speaking to each other and to the newborn infant.

#### *Infants' crying behavior*

The infants cried more when in skin-to-skin contact with their mothers than in skin-to-skin contact with their fathers ( $p=0.002$ ); see Fig. 3. The amount of crying decreased significantly

between 10 and 15 minutes during skin-to-skin contact with the infants' fathers but not during skin-to-skin contact with the infants' mothers ( $p=0.032$ ). The time during which the infant was silent did not differ significantly between the infants in skin-to-skin contact with their mothers and those in skin-to-skin contact with their fathers ( $p=0.186$ ) (I).



**Figure 3.** Minutes of newborns' crying from 5 to 30 minutes after birth (mean, SEM) in skin-to-skin-contact with mother or father.

#### *Girls' and boys' crying behaviour in skin-to-skin contact with mother or father*

During the observation period, girls cried significantly more than boys ( $p=0.02$ ). Additionally, girls cried significantly more when in skin-to-skin contact with the mother than in skin-to-skin contact with the father ( $p=0.004$ ). Girls cried for a mean of 13 minutes in skin-to-skin contact with the mother and for a mean of 6 minutes in skin-to-skin contact with the father. In contrast, no significant differences were found in crying behaviours among boys when they were in skin-to-skin contact with the mother or in skin-to-skin contact with the father ( $p=0.251$ ). Boys cried for a mean of 7 minutes in skin-to-skin contact with the mother and for a mean of 3 minutes when in skin-to-skin contact with the father (II).

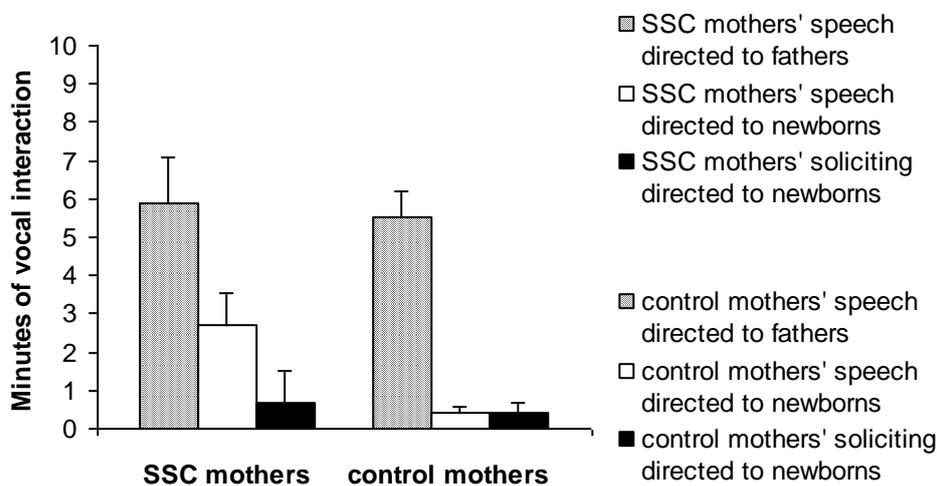
### 5.1.3 Parent-newborn infant vocal interaction

Parents' first speech after birth preceded the newborns' first soliciting in the skin-to-skin contact with fathers ( $p=0.010$ ) and in the skin-to-skin-contact with mothers ( $p=0.043$ ).

In skin-to-skin contact, 9 mothers and 9 fathers responded to the infants' soliciting with a soliciting response. Interestingly, all newborns except 5 out of 37 performed soliciting calls. When the infants (2 in skin-to-skin contact with father and 3 in skin-to-skin contact with mother) did not perform soliciting calls, neither did their mother or father. The newborns in skin-to-skin contact with fathers entered into a relaxed state at a mean of 5.5 minutes after birth, significantly earlier compared with infants in skin-to-skin contact with mothers ( $p=0.029$ ). The latter group of infants slept or relaxed at a mean of 11.25 minutes after birth.

*Effect of skin-to-skin contact on mothers' vocal interaction*

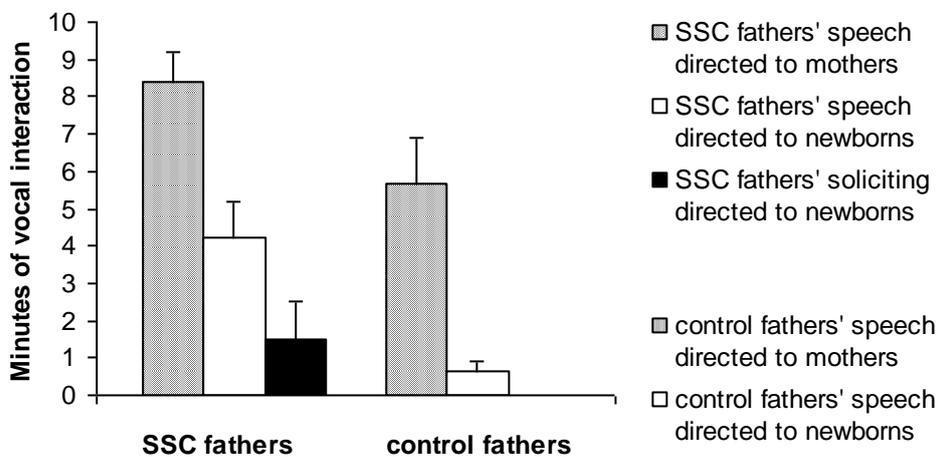
The amount of the mothers' vocal interaction is shown in Fig. 4. Mothers' speech directed to the father did not differ between mothers who had skin-to-skin contact with their infants compared with the control mothers who did not have skin-to-skin contact. In contrast, mothers who had skin-to-skin contact directed significantly more speech to the infant than the control mothers ( $p=0.009$ ). The mothers' first soliciting sounds did not differ between the groups ( $p=0.856$ ) and occurred at a mean of 13 minutes and the amount of soliciting responses in mothers did not differ between groups (I).



**Figure 4:** Bar plot showing mothers' total amount of vocal interaction when having the infant in skin-to-skin-contact and control mothers' total amount of vocal interaction when not having the infant in skin-to-skin contact during the observation period 5 to 30 minutes (mean, SEM) after birth.

### *Effect of skin-to-skin contact on fathers' vocal interaction*

The amount of the fathers' vocal interaction is shown in Fig. 5. The fathers who had skin-to-skin contact with their infants directed significantly more speech to the mothers and to the infants compared with control father ( $p=0.046$  and  $p=0.003$ , respectively). Fathers who had skin-to-skin contact performed significantly more soliciting sounds than control fathers, who performed no soliciting sounds at all ( $p=0.010$ ) The first soliciting sounds of skin-to-skin contact fathers occurred at a mean of 18.9 minutes. Fathers' soliciting sounds occurred for a mean of 1.4 minutes in skin-to-skin contact with their newborn infants and did not occur at all in control fathers.

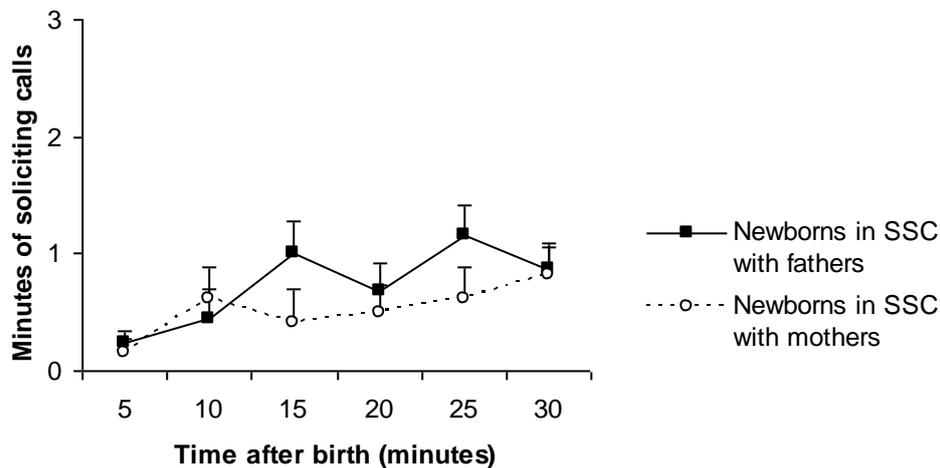


**Figure 5:** Bar plot showing fathers' total amount of vocal interaction when having the newborn in skin-to-skin-contact and control fathers' total amount of vocal interaction when not having the infant in skin-to-skin-contact during the observation period 5 to 30 minutes (mean, SEM)

### *Infants' soliciting*

The infant started to perform soliciting calls at a mean of 12.33 minutes in skin-to-skin contact with fathers and at a mean of 14.71 minutes in skin-to-skin contact with mothers. The amount of soliciting sounds performed by the newborns increased over time during the observation period ( $p=0.032$ ) Fig. 6. In the 32 infants who performed soliciting calls, the sounds occurred for a mean of 4.16 minutes for infants in skin-to-skin contact with their fathers and for a mean of 2.97 minutes for infants in skin-to-skin contact with their mothers. The infants continued to perform soliciting sounds during the entire observation period, as a response after parental communication.

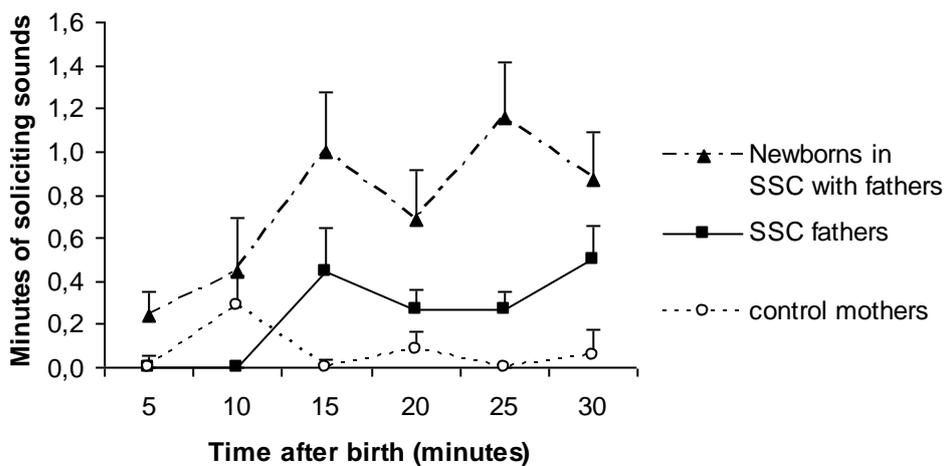
During the skin-to-skin contact, the newborn touched the parent's breast, nipple, or both for a mean of 13.8 minutes in skin-to-skin contact with fathers and for a mean of 18.25 minutes in skin-to-skin contact with mothers (I).



**Figure 6.** Minutes of newborns' soliciting sounds from 5 minutes to 30 minutes after birth (mean SEM) in skin-to-skin contact with mother or father.

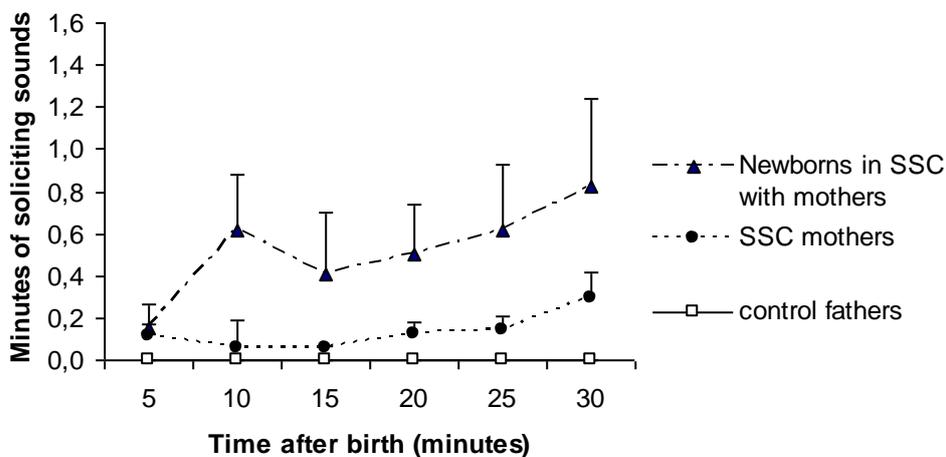
*Mothers' and fathers' soliciting in skin-to-skin contact with the infant or not*

In skin-to-skin contact with fathers the infants' soliciting correlated with their fathers' soliciting sounds ( $R_s=0.499$ ,  $p=0.025$ ). The pattern of parent-infant soliciting calls when newborns were in skin-to-skin contact with their fathers is shown in Fig. 7.



**Figure 7:** Minutes of soliciting sounds from 5 to 30 minutes after birth (mean, SEM) within the family members, when the newborn is kept in skin-to-skin-contact with fathers.

In skin-to-skin contact with mothers the infants' soliciting correlated even more strongly with their mothers' soliciting sounds ( $R_s=0.639$ ,  $p=0.006$ ). The pattern of parent-infant soliciting calls when the newborns were in skin-to-skin contact with their mothers is shown in Fig. 9. The parents' response rate to infants' soliciting calls differed significantly between fathers and mothers in skin-to-skin contact ( $p=0.049$ ), and was more frequent in fathers in skin-to-skin contact. Together, these data show a reciprocal parent-infant interaction, and even if fathers performed more soliciting sounds than mothers, the relationship between mothers' and infants' soliciting was the strongest (I).



**Figure 8:** Minutes of soliciting sounds from 5 to 30 minutes after birth (mean, SEM) within the family members, when the infant is kept in skin-to-skin-contact with mothers.

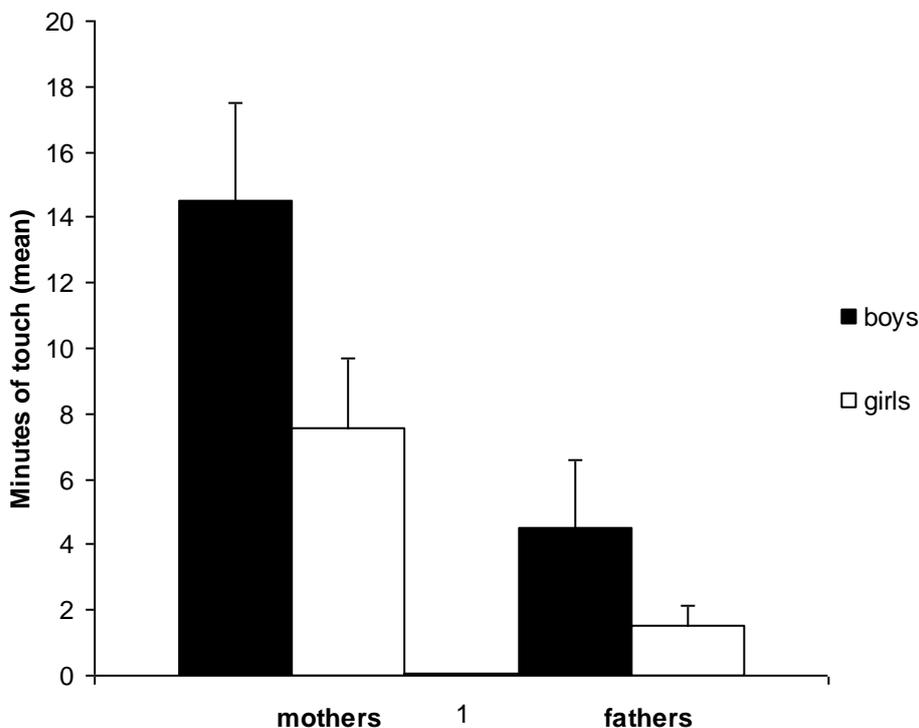
*In summary*

It was found that skin-to-skin contact elicited vocal parent-infant interaction and it occurred in a specific order. When placed in skin-to-skin contact and exposed to the parents' speech, the infants initiated communication with soliciting calls within approximately 15 minutes of age. The parents responded contingently by performing soliciting sounds. Infants in skin-to-skin contact with fathers cried less than infants in skin-to-skin-contact with mothers. Additional findings are that both fathers and mothers in skin-to-skin-contact with the newborn after cesarean section are more open for vocal interaction than parents without such contact. These findings give reason to encourage parents to keep the newborn infant in skin-to-skin contact after planned cesarean section, to support the onset of the first vocal communication.

#### 5.1.4 Mothers' and fathers' tactile interactive behaviour

a) *Touching*. The amount of mothers and fathers touching of their newborn girl or boy are shown in Figure 9. Mothers in skin-to-skin contact touched their infants significantly more than fathers in skin-to-skin contact ( $p=0.001$ ). Furthermore, mothers touched girls significantly less than boys ( $p=0.038$ ). Mothers touched girls for a mean of 7.59 minutes and boys for a mean of 14.5 minutes.

There was no significant difference in the time fathers spent touching girls or the time they spent touching boys ( $p=0.232$ ). Touching occurred for a mean of 1.5 minutes in girls and for a mean of 4.5 minutes in boys (Fig. 7). Mothers performed significantly more finger-tipping touch than fathers ( $p<0.01$ ). The sex of the newborns did not influence this behaviour in mothers or the fathers (II).

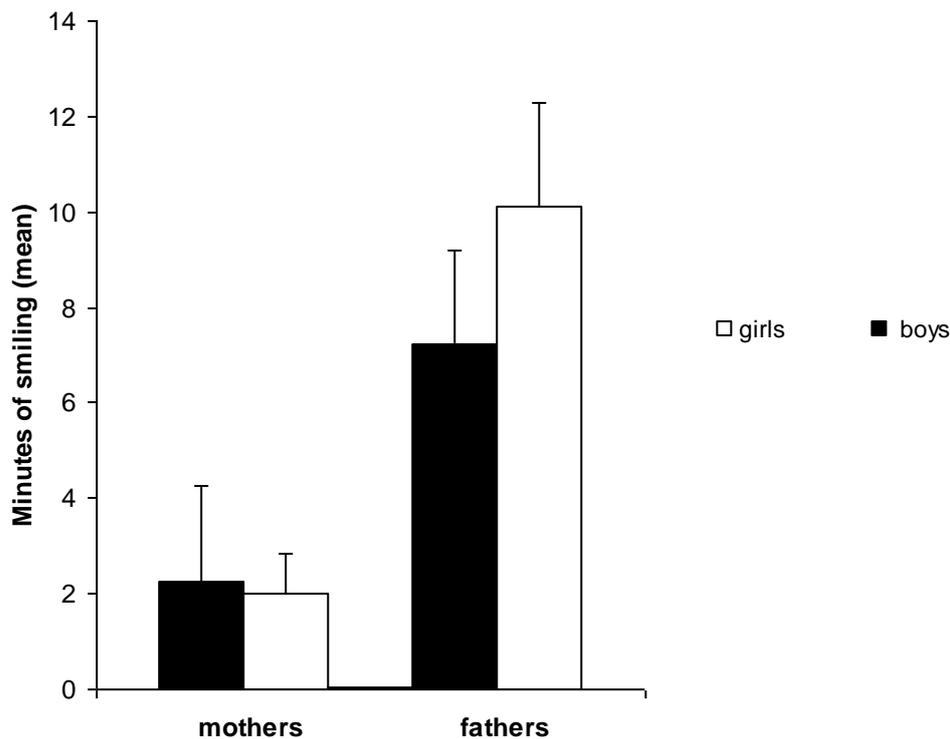


**Figure 8.** Bar plots showing the total amount of touching (mean, SEM) engaged in by mothers or fathers with the newborn girl or boy.

b) *Smiling*. Mothers in skin-to-skin contact smiled significantly less during the observation period than fathers in skin-to-skin contact ( $p=0.001$ ). When this behaviour was analyzed separately to determine differences between mothers smiling at girls and mothers smiling at

boys, no significant difference was found ( $p=0.53$ ). Mothers' smiling occurred for a mean of 2 minutes in skin-to-skin contact with girls and for a mean of 2.25 minutes in skin-to-skin contact with boys (Fig. 10).

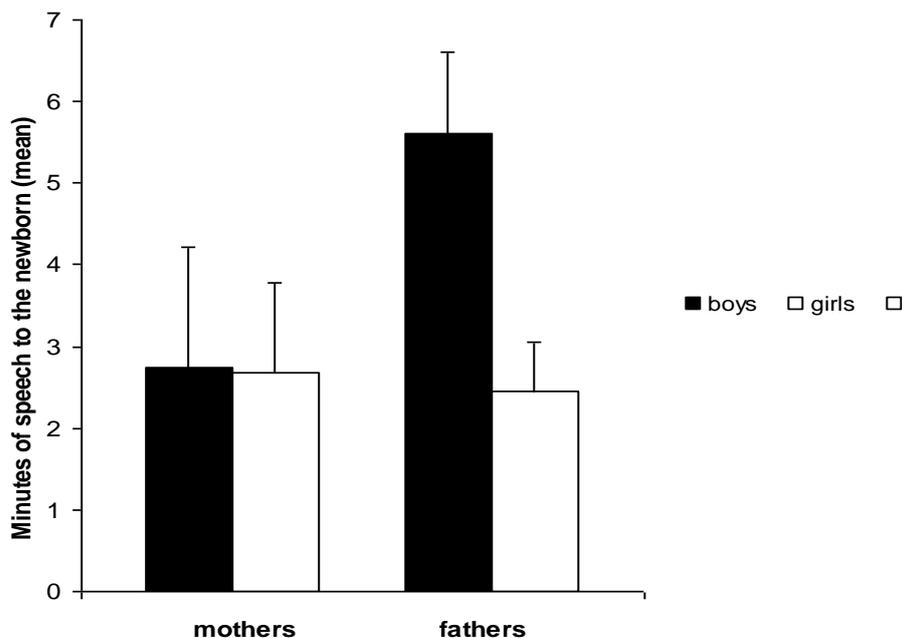
No significant differences were found between the length of time fathers smiled at girls or at boys. Fathers' smiling occurred for a mean of 10 minutes in skin-to-skin contact with girls and for a mean of 7 minutes in skin-to-skin contact with boys. However, there was a significant negative correlation between the amount of smiling in fathers and the crying in newborn girls ( $R_s=-0.601$   $p=0.005$ ) (II).



**Figure 10.** Bar plots showing the total amount of smiling (mean, SEM) behavior of mothers and fathers engaged in skin-to-skin contact with the newborn girl or boy.

c) *Kissing*. No significant differences were found between mothers kissing their infants and fathers kissing their infants. In skin-to-skin contact 5 of the 17 mothers and 6 of the 20 fathers kissed the newborn during the first 30 minutes after birth. For mothers, this behaviour occurred for a mean of 1.5 minutes and for fathers it occurred for a mean of 1.75 minutes (II).

d) *Speech directed towards the newborn.* The mothers length of directed speech toward the newborn girls and boys did not differ. In fact, fathers directed significantly less speech towards girls than towards boys, ( $p=0.042$ ). It occurred for a mean of 2.5 minutes towards girls and for a mean of 5.6 minutes towards boys (II) (Fig. 11).



**Figure 11.** Bar plots showing total amount of speech (mean, SEM) directed by mothers and fathers toward the newborn boy or girl during skin-to-skin contact.

### 5.1.5 Breast-seeking behaviours in newborns

*Infants' breast seeking and breastfeeding behaviour in skin-to-skin contact with mother or father*

There were no significant differences in the appearance of the first strong rooting or breast-massaging movements between infants (regardless of their sex), in skin-to-skin contact with their mothers or their fathers, Table 6.

Infants' first breastfeeding in skin-to-skin contact with mothers appeared significantly earlier than if in skin-to-skin contact with the father ( $p=0.018$ ), (Figure 12). For infants in skin-to-skin contact with the mother ( $n=17$ ) the first breastfeeding occurred at a median of 117.5 minutes, and for infants in skin-to-skin contact with the father ( $n=20$ ) at a median of 235 minutes.

Infants' first breastfeeding appeared significantly earlier if they had been continuously in skin-to-skin contact with the mother during the first 30 minutes after birth.

**Table 6.** First appearance of a specific breast-seeking behaviour during the first hours of life after Caesarean section. Comparison of the development of feeding behaviour between infants in skin-to-skin contact with a) mother or father and b) between girls and boys irrespective of placement with mother or father. Data presented as Median minutes and interquartile distances (Q<sub>25</sub>-Q<sub>75</sub>) values.

Variable	Newborn breast-seeking behaviour in SSC with mother or father			Girls and boys breast seeking behaviour in SSC with parent		
	<i>Mothers (n=17)</i>	<i>Fathers (n=20)</i>	<i>p</i>	<i>Girls (n=20)</i>	<i>Boys (n=17)</i>	<i>p</i>
	Md (Q <sub>25</sub> -Q <sub>75</sub> )	Md (Q <sub>25</sub> -Q <sub>75</sub> )		Md (Q <sub>25</sub> -Q <sub>75</sub> )	Md (Q <sub>25</sub> -Q <sub>75</sub> )	
First time of strong rooting	12.5 (5.5-19.0)	14.75 (4.6-20.6.3)	0.603	7.0 (3.63-15.5)	17.0 (11.0-21.0)	0.035
First time of breast massage movements	11.0 (7.13-16.6)	16.0 (4.4-27.0)	0.576	7.75 (3.5-15.5)	18.5(9.9-26)	0.027
First breastfeeding	117.5 (70-208)	235.1(120-430)	<b>0.018</b>	157 (101-304)	170 (74-345)	0.886

*Girls' and boys' breast seeking and breastfeeding behaviour in skin-to-skin contact with parents (II)*

The first strong rooting behavior in girls (n=20) appeared significantly earlier than in boys (p=0.035) in skin-to-skin contact with either parent. For girls it appeared at a median of 7 minutes, and for boys (n=17) at a median of 17 minutes. There were no significant differences in the median duration of rooting behaviours between girls and boys (p=0.56), either in skin-to-skin contact with the mother (p=0.301) or in skin-to-skin contact with the father (p=0.661). For girls, the median duration for this behaviour was 5 minutes and for boys 6 minutes. There was also a statistical difference in the appearance of the first breast-massaging movements between girls and boys in skin-to-skin contact with mother or father (p=0.027), shown in Table 2. The first breastfeeding for girls appeared at a median of 157 minutes, and for boys at a median of 170 minutes, this difference was not significant (p=0.886) shown in Table 52. (II)

*Girls' and boys' breast seeking and breastfeeding behaviour in skin-to-skin contact with mother or father (II)*

To further analyze differences in girls' and boys' first breastfeeding in skin-to-skin contact with the mother or in skin-to-skin contact with the father, a sub-group analysis was performed. Girls (n=11) who were in skin-to-skin contact with the mother during the first 30 minutes after birth, started their first breastfeeding significantly earlier than girls (n=9) who had been in skin-to-skin contact with the father (p=0.037) during the first 30 minutes. No significant difference was found among boys (p=0.525). (II)

*In summary*

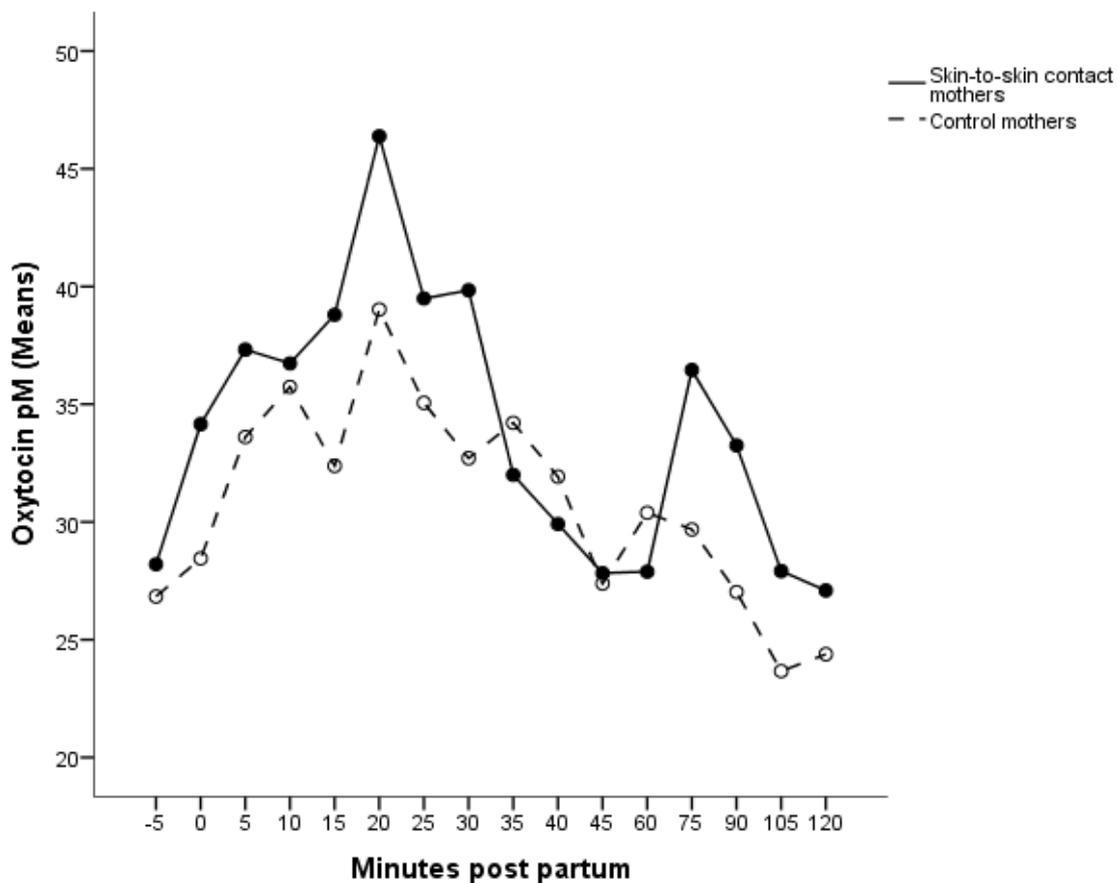
Mothers showed more tactile stimulation while fathers engaged more in speech, in particular directed to the newborn boy. The fathers showed more signs of affection and communicated more when in skin-to-skin contact with their newborn compared to mothers in skin-to-skin contact with their newborn. Girls cried less when in skin-to-skin contact with the father than with the mother.

Skin-to-skin contact with the mother accelerated the time point for the infants' first breastfeeding as compared to skin-to-skin contact with the father.

Our data support that uninterrupted skin-to-skin contact with the mother facilitates the initiation of breastfeeding in the mother-infant dyad exposed to a planned Caesarean section.

### 5.1.6 Levels of oxytocin in mothers

In order to compare oxytocin levels in mothers having received skin-to-skin contact to control mothers, a mean value based on 16 oxytocin samples collected between 5 minutes before birth and 120 minutes after birth, was created. In addition to comparing mothers having had skin-to-skin contact with the controls, the effect of oxytocin infusion was also studied.



**Figure 12.** All mothers in SSC with and without oxytocin infusion (n=15) and control mothers with and without oxytocin infusion (n=19).

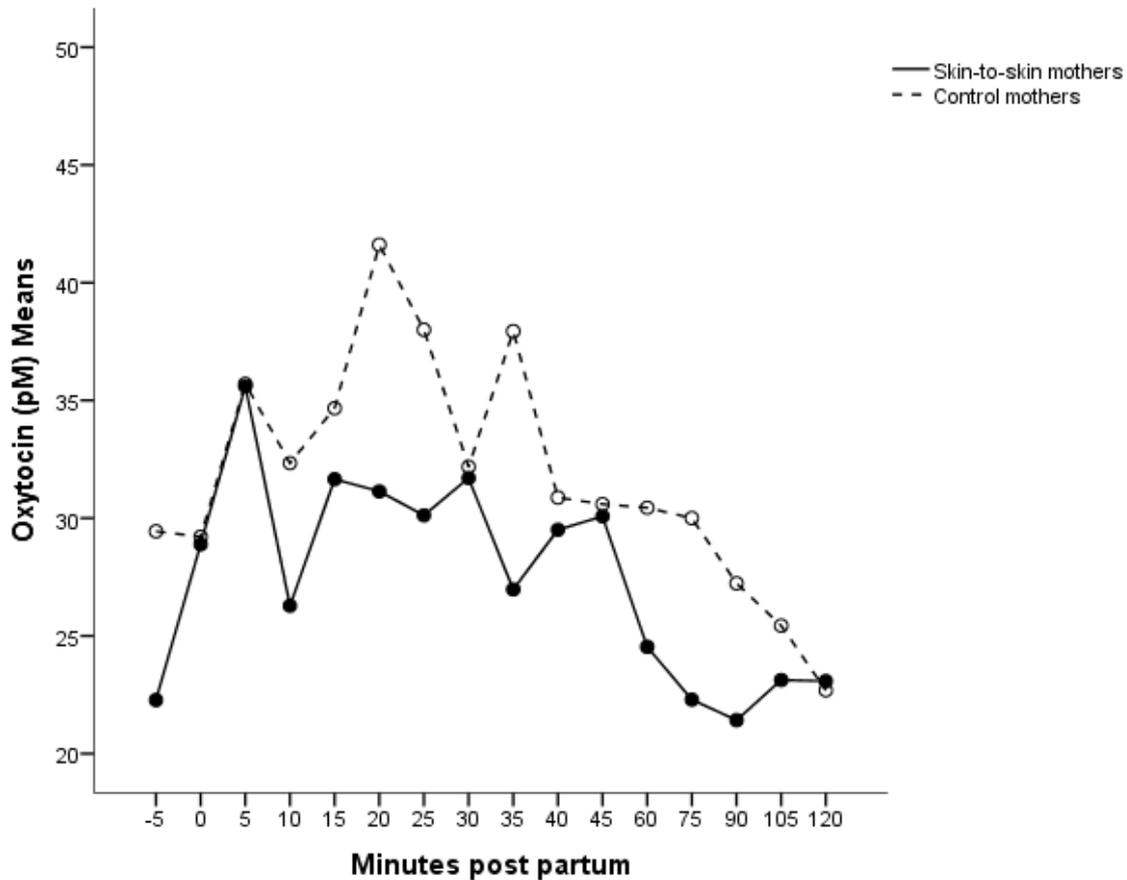
#### *Levels of Oxytocin in all mothers*

When including all mothers with and without oxytocin infusion, there was no difference in oxytocin levels between skin-to-skin contact mothers (n=15) and control mothers (n=19) ( $p=0.329$ ). Still the pattern of oxytocin levels differed significantly over time ( $p < 0.001$ ).

When oxytocin levels recorded at 60 minutes were compared with the basal oxytocin levels there was no significant difference ( $p=0.386$ ), indicating that the oxytocin levels had returned to basal level. (Fig.12).

*Skin-to-skin mothers versus control mothers without oxytocin infusion*

When comparing skin-to-skin contact mothers without oxytocin infusion (n=8) to control mothers also without oxytocin infusion (n=7) there was no significant difference in mean oxytocin levels between the groups. The mean difference was 4.355 pM (p=0.400) (Fig 13).

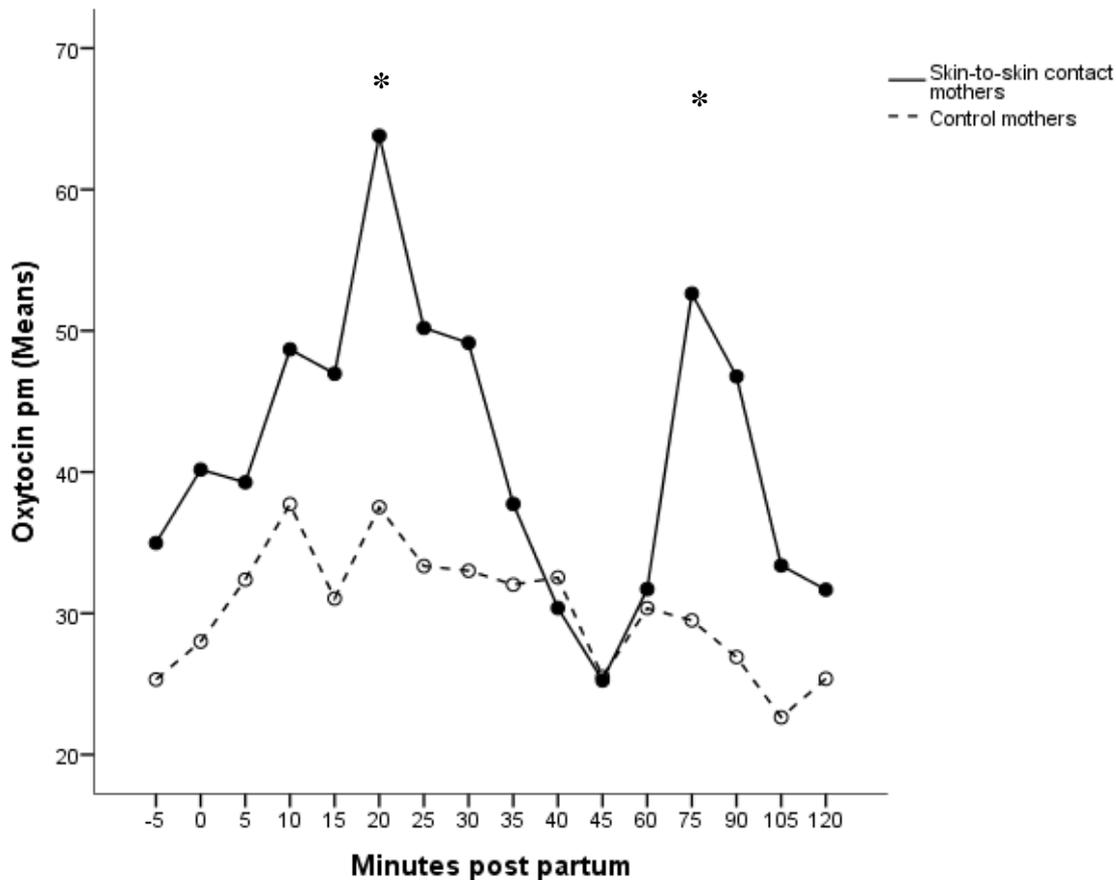


**Figure 13.** Mean oxytocin level in SSCM without oxytocin infusion (n=8) versus CONM without oxytocin infusion (n=7).

*Skin-to-skin mothers versus control mothers with oxytocin infusion*

There was a significant difference in oxytocin levels between skin-to-skin mothers (n=7) and control mothers (n=12), who had received oxytocin infusion. The mean difference was -11.22 pM (95%CI 1.64-20.79) (p= 0.023) (Fig 14). In addition there was a significant difference in the oxytocin pattern over time (p<0.001). The oxytocin pattern was biphasic and a significant rise versus basal levels was recorded at 20 and 75 minutes.

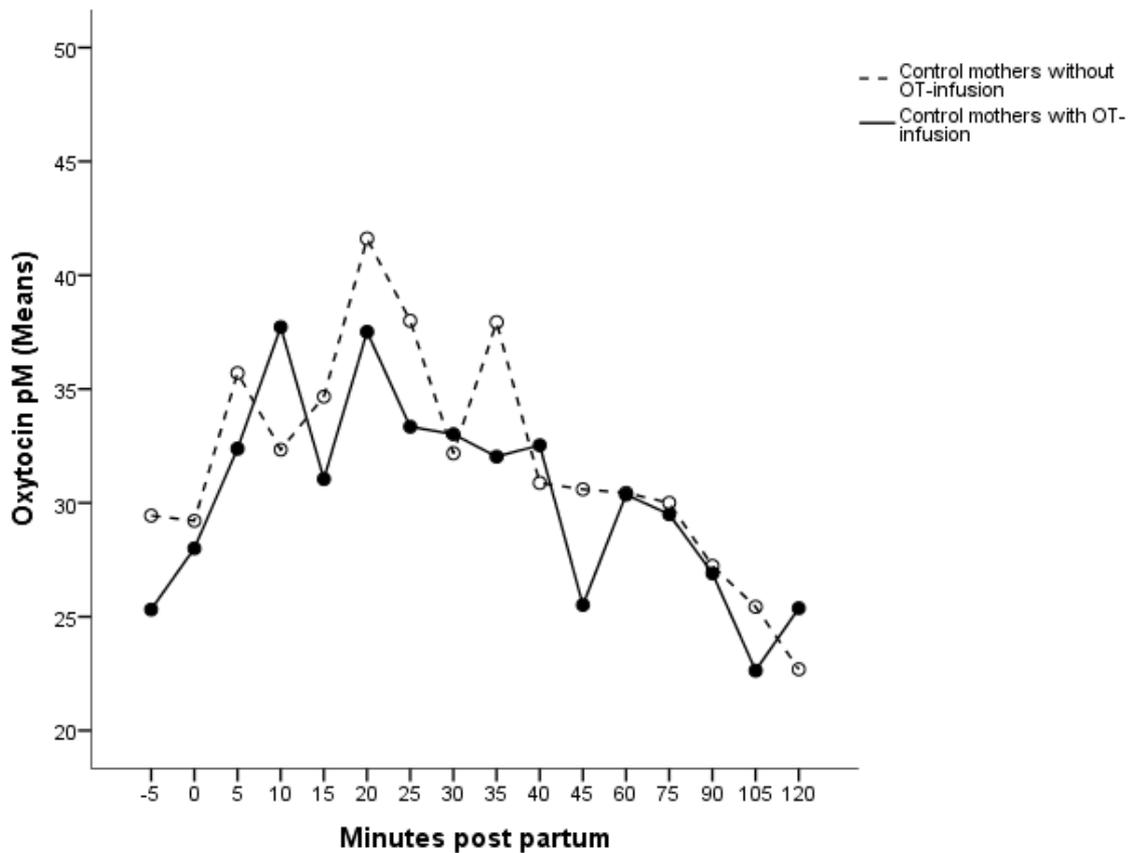
When oxytocin levels recorded at different time points were compared, some significant differences were found. The oxytocin levels differed at 15 minutes ( $p=0.045$ ), at 20 minutes ( $p=0.001$ ), at 25 minutes ( $p=0.034$ ), at 30 minutes ( $p=0.043$ ), at 75 minutes ( $p=0.004$ ) and at 90 minutes ( $p=0.013$ ). No differences were observed at 40, 45 and 60 minutes.



**Figure 14.** Mean oxytocin level in SSCM with oxytocin infusion ( $n=7$ ) versus CONM with oxytocin infusion ( $n=12$ ). \*  $p<0.05$

*Control mothers with or without oxytocin infusion*

When analyzing the differences in oxytocin levels between control mothers with oxytocin infusion ( $n=12$ ) and without oxytocin infusion ( $n=7$ ), no significant differences were found between groups ( $p=0.740$ ). The mean difference was 1.573 pM (Fig 15). Still, the pattern of oxytocin levels differed significantly over time ( $p=0.004$ ).

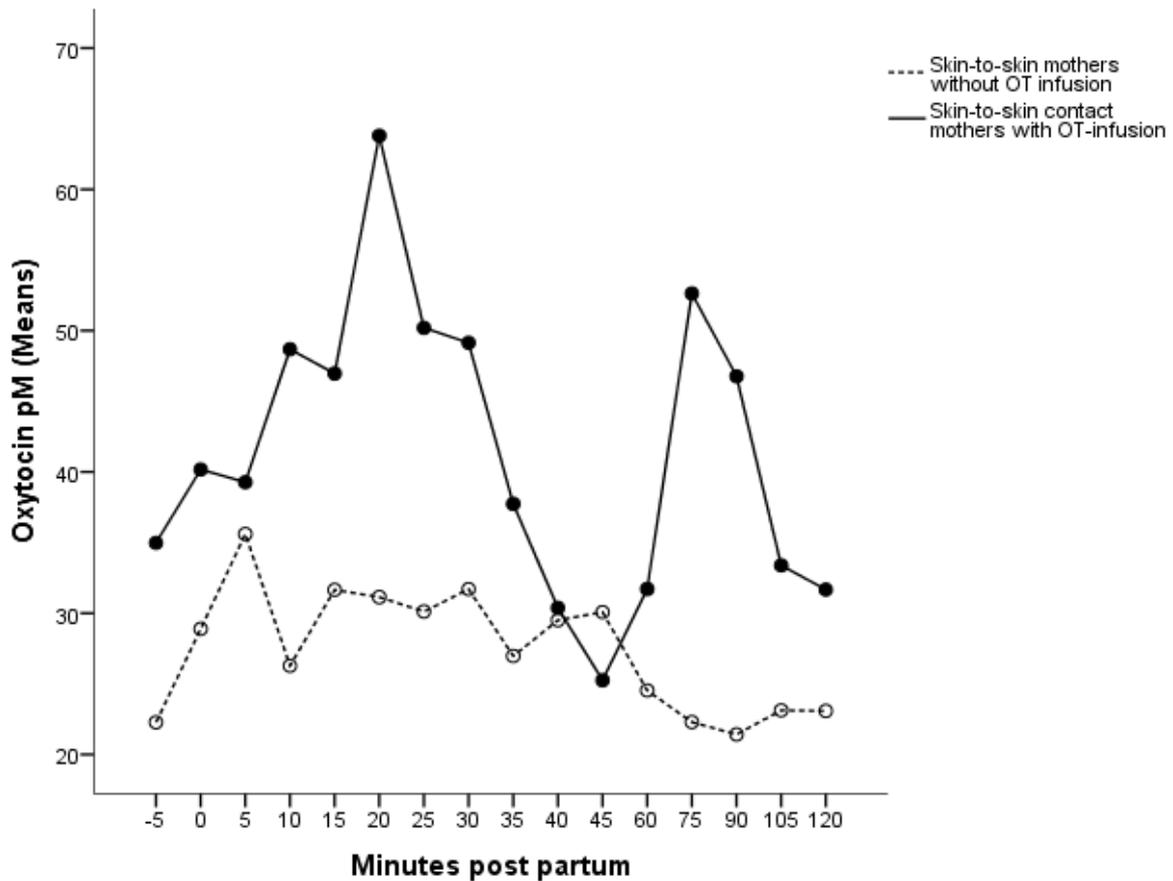


**Figure 15.** Mean oxytocin level in CONM with oxytocin infusion (n=12) versus control mothers without oxytocin infusion (n=7).

*Skin to skin mother with or without oxytocin infusion*

When analyzing the differences in oxytocin levels between skin-to-skin mothers with (n=7) and without oxytocin infusion (n=8), a significant difference was found (p=0.021). In addition the pattern of oxytocin levels differed significantly over time (p=0.013).

The mean difference was -14.004 pM (95% CI-24.421- -3.587) (p=0.010). Thus, skin-to-skin mothers with oxytocin infusion showed higher oxytocin levels than skin-to-skin mothers without oxytocin infusion (Fig16). When individual time points were compared, oxytocin levels differed significantly between groups, at 10 minutes (p=0.010), at 20 minutes (p=0.000), at 25 minutes (p=0.021), at 30 minutes (p=0.044) at 75 minutes (p= 0.001) and at 90 minutes (p=0.004).



**Figure 16.** Mean oxytocin level in SSCM with oxytocin infusion (n=7) versus SSCM without oxytocin infusion (n=8).

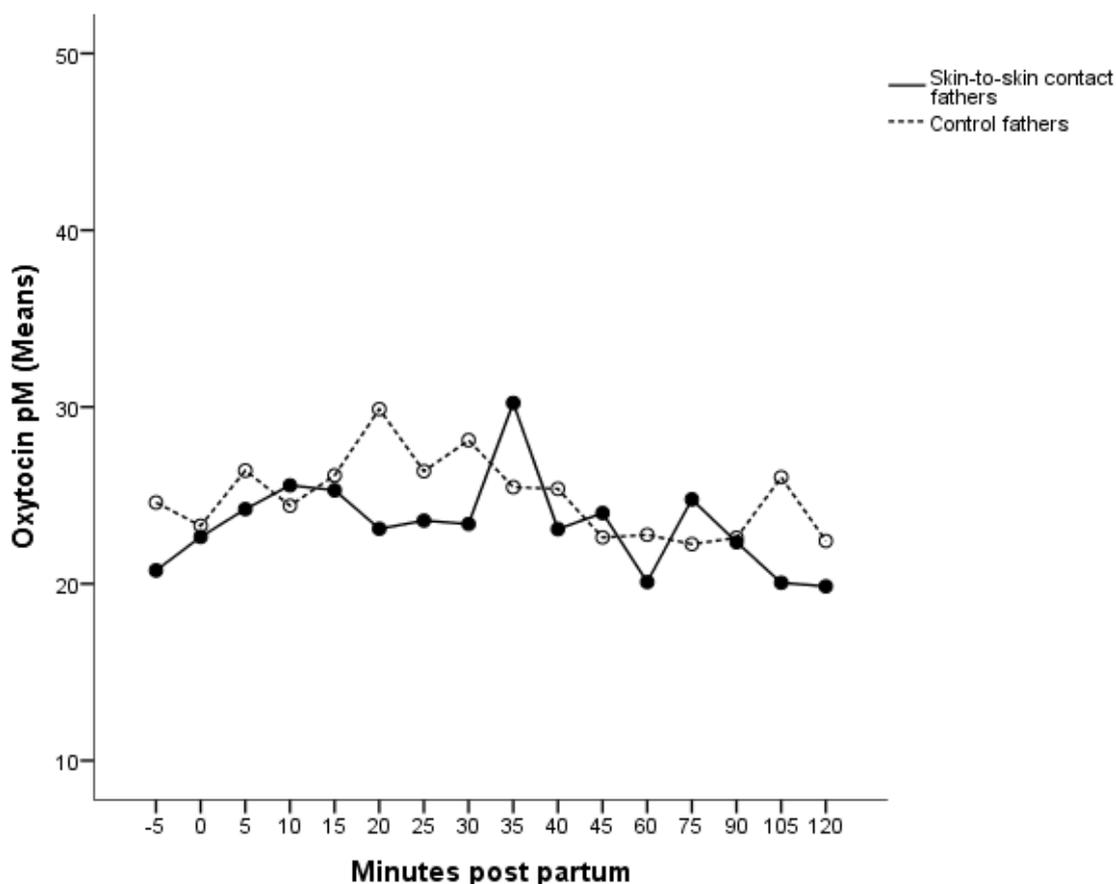
When 60 minute oxytocin levels were compared with basal levels in all mothers, there was no significant difference, indicating that the oxytocin level had returned to basal level. The mean difference was -2.048 pM (p=0.386).

### 5.1.7 Breastfeeding and oxytocin

During the first two hours observation period, significantly more infants breastfed in the skin-to-skin contact group with mothers compared to infants who had been in skin-to-skin contact with fathers (p = 0.050). The mean time for first breastfeeding occurred at 83.2 min (SD± 27.9) and might explain the oxytocin rise observed at 90 minutes. In the breastfeeding women a significant peak of oxytocin occurred between the oxytocin levels recorded at 75 and 90 minutes post partum (p= 0.023). Oxytocin levels rose in response to breastfeeding in both control and skin-to-skin mothers, in the mothers who had received oxytocin infusion. No effect on oxytocin levels was observed in the mothers in response to breastfeeding in mothers who had not received oxytocin infusion in either of the groups.

### 5.1.8 Levels of oxytocin in fathers

In order to compare oxytocin levels in fathers having received skin-to-skin contact and control fathers a mean value based on 16 oxytocin samples collected between 5 minutes before birth and 120 minutes after birth was created. When comparing fathers with skin-to-skin contact (n=18) to control fathers (n=13), no significant difference was found in mean level of oxytocin. The mean difference was -1.60 pM (p=0.400). There was however, a significant difference in the pattern of oxytocin levels over time (p=0.008) (Fig. 17). Some differences between oxytocin levels were found when comparing basal levels of oxytocin with oxytocin levels obtained at the other time points within groups. A significant rise was observed at 35 minutes in skin-to-skin fathers; the mean differences was 9.469 (p=0.005) and a significant increase of oxytocin levels was found at 20 minutes post partum in the control group; the mean differences was 5.283 (p=0.026).



**Figure 17.** Mean oxytocin level in SSCF (n=18) versus CONF (n=13).

When the 60 minute oxytocin levels were compared with basal levels in all fathers, there was no significant difference, indicating that the oxytocin levels had returned to basal. The mean difference was 1.148 (p=0.250).

### 5.1.9 Personality profile in mothers after childbirth

The mothers mean KSP scores of the fifteen subscales in the four groups at 2 days post partum are displayed in Table 7.

#### *Comparisons between mothers without oxytocin infusion and the normative group*

In general, mothers in both skin-to-skin contact and control mothers, who had not been exposed to administration of oxytocin infusion differed from the normative group at 2 days and showed significantly lower scores on psychic anxiety, psychasthenia and detachment than the normative group.

The control mothers without oxytocin infusion, scored significantly lower on psychic anxiety, psychanesthesia and inhibition of aggression compared to the normative group. Additionally, control mothers without oxytocin infusion, showed lower scores on social desirability and guilt compared to the normative group.

The skin-to-skin contact mothers without oxytocin infusion, scored significantly higher on indirect aggression and verbal aggression compared to the normative group.

#### *Comparisons between mothers with oxytocin infusion and the normative group*

The control mothers with oxytocin infusion, differed from the normative group at 2 days. The control mothers with oxytocin infusion, scored significantly lower on somatic anxiety, muscular tension, psychic anxiety, psychasthenia, inhibition of aggression, detachment, irritability and guilt than the normative group. In addition, the control mothers with oxytocin infusion, exhibited a significantly higher score on socialization compared to the normative group.

The skin-to-skin contact mothers with oxytocin infusion differed from the normative group at 2 days. The skin-to-skin contact mothers with oxytocin infusion, scored significantly lower on psychic anxiety, psychanesthesia, detachment and guilt compared to the normative group. Additionally, skin-to-skin contact mothers with oxytocin infusion, scored significantly higher on monotony avoidance and indirect aggression compared to the normative group.

**Table 7.** KSP score for the mothers without oxytocin infusion (-OT) and with oxytocin infusion (+OT) in the Control (Con) and Skin-to-skin contact group (SSC)

KSP subscales	<i>Control group</i>		<i>Skin-to-skin contact group</i>		<i>p-value</i>			
	Con-OT	Con+OT	SSC-OT	SSC+OT	Con-OT	SSC-OT	Con-OT	Con+OT
	( <i>n</i> =7)	( <i>n</i> =12)	( <i>n</i> =8)	( <i>n</i> =7)	vs	vs	vs	vs
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Con+OT	SSC+OT	SSC-OT	SSC+OT
				<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	
Somatic Anxiety	47.70 (5.29 )	<b>41.66</b> (3.60)	50.79 (11.46)	46.38 (3.68 )	<b>0.017</b>	0.304	0.522	<b>0.022</b>
Muscular Tension	46.22 (5.12 )	<b>42.54</b> (3.64)	49.31 (10.76)	47.30 (5.98)	0.115	0.660	0.497	0.068
Psychic Anxiety	<b>44.52</b> (5.12)	<b>41.45</b> (9.29)	<b>43.47</b> (7.53 )	<b>43.15</b> (3.03)	0.525	0.910	0.807	0.651
Psychasthenia	<b>40.64</b> (10.93)	<b>42.95</b> (8.55)	<b>41.85</b> (7.43)	<b>43.76</b> (9.16 )	0.640	0.651	0.795	0.859
Inhibition of Aggression	<b>43.06</b> (10.05)	<b>40.32</b> (11.58)	46.67 (7.68 )	<b>45.33</b> (9.76)	0.636	0.764	0.428	0.385
Impulsivity	49.39 (6.52 )	52.47 (3.30)	51.06 (6.73)	53.29 (9.23)	0.286	0.585	0.626	0.808
Monotony Avoidance	54.06 (9.13 )	53.31 (4.62)	<b>56.92</b> (6.65)	<b>56.38</b> (9.26)	0.842	0.894	0.480	0.400
Detachment	53.24(8.96)	<b>45.11</b> (5.79)	<b>43.08</b> (8.21 )	<b>41.42</b> (6.54)	<b>0.045</b>	0.669	<b>0.033</b>	0.259
Socialization	52.20 (8.82 )	<b>56.49</b> (5.15)	52.69 (9.00 )	52.62 (5.85)	0.242	0.986	0.916	0.181
Social Desirability	<b>43.47</b> (10.95)	50.95 (9.91)	48.63 (10.50)	48.15(13.73)	0.175	0.938	0.355	0.642
Indirect Aggression	53.21 (10.95 )	47.33(3.77)	55.78 (11.85)	<b>56.05</b> ( 9.77)	0.143	0.962	0.660	<b>0.027</b>
Verbal Aggression	51.43 (6.96 )	47.29 (6.86)	56.28 (8.78)	52.11(12.55)	0.254	0.446	0.251	0.342
Irritability	52.19 (9.47 )	<b>44.65</b> (9.50)	48.63 (9.51)	52.94 (8.44 )	0.137	0.362	0.469	0.091
Suspicion	53.04 (9.05 )	47.31(10.02)	48.26 (12.62)	<b>45.88</b> (8.75 )	0.256	0.678	0.412	0.770
Guilt	<b>44.93</b> (5.28 )	<b>35.51</b> (18.61)	45.45 (9.97)	<b>42.24</b> (6.90)	0.218	0.481	0.897	0.382

*Comparisons between skin-to-skin contact mothers without oxytocin infusion and control mothers without oxytocin infusion*

Interestingly, the skin-to-skin contact mothers without oxytocin infusion, exhibited significantly lower on the detachment score compared to the control mothers without oxytocin infusion ( $p=0.033$ ). The mean score for the skin-to-skin contact mothers was 43.1 (SD 8) and for the control mothers the mean was 53.2 (SD 9).

*Skin-to-skin contact mothers with oxytocin infusion compared to control mothers with oxytocin infusion*

The skin-to-skin contact mothers with oxytocin infusion, scored significantly higher on somatic anxiety and on indirect aggression compared to the control mothers with oxytocin infusion.

*In summary*

The plasma oxytocin levels in both mothers and fathers showed a slight rise lasting for 60 minutes after birth irrespective of being in skin to skin contact with the infants or not. These data suggest that there might be a period immediately after birth, when both mothers and fathers have high oxytocin levels, which might facilitate bonding to the newborn. The present study also suggests that oxytocin infusion causes a potentiated effect on maternal plasma oxytocin levels when in skin-to-skin contact and may contribute to lower self reported scores on the detachment scale and the somatic anxiety scale in KSP two days post partum.

During the skin-to-skin contact with the mother, the new family should be encouraged to stay in close contact to enable parent-infant interaction and breastfeeding during this specific period.

#### **5.1.10 Paper IV**

##### **Effect of skin-to-skin contact between mothers and infant with latch-on breastfeeding problems**

*Background data*

The mothers in the experimental group was Md 31(29-34) years of age and the corresponding figure for the control group was 33 (29-35) years of age. There were no

significant differences between the two groups in terms of background (Table 8a and b), nutrition and way of giving breast milk /supplements, use of pacifier and maternal feeding intentions (Table 9 and 10). There were no differences between the exposure to caring routines and interventions in connection with birth and during the maternity stay, even though only half of the infants had skin-to-skin to skin contact after birth and 30-40% latched on within two hours of birth. A large number of infants had been exposed to “hands-on latch intervention” (Table 9).

**Table 8a.** Socio-economic and obstetric background data collected from medical records

Characteristics	Experiment group	Control group
	n=53 No (%)	n=50 No (%)
Primipara	43 (84)	36 (72)
Multipara	8 (16)	14 (28)
<b>Education</b>		
Primary	4 (8)	4 (9)
Secondary	18 (37)	17 (36)
Universtiy	27 (55)	26 (55)
<b>Civil status</b>		
Married or cohabiting	50 (98)	48 (98)
<b>Obstetric data</b>		
Pre-eclampsia	8 (16)	7 (15)
Induction of labor	11 (22)	6 (12)
Normal vaginal delivery	23 (45)	31 (62)
Vacuum extraction	7 (14)	3 (6)
Forceps	1 (2)	0 (0)
Caesarean section birth		
-Elective	9 (18)	10 (20)
-Urgent	11 (22)	6 (12)
Presentation		
Head	44 (88)	44 (90)
Breech/fot	6 (12)	5 (10)
Oxytocin infusion	39 (83)	29 (73)
Meconium stained in amniotic fluid	12 (24)	15 (31)
Ruptured membranes >24h	6 (12)	7 (15)
<b>Anaesthesia <sup>1)</sup></b>		
No anaesthesia	12 (12)	14(14)
General anaesthesia	2 (4)	2 (4)
Epidural block	21 (41)	16 (31)
Spinal block	16 (31)	13 (27)
Pudendal block	4 (8)	2 (4)
Nitros oxide	25 (51)	33 (70)
Bleeding post partum (ml) Md (Q <sub>1, 3</sub> )	465(317-700)	405(310-582)
<b>Breast/nipple status first days post partum</b>		
-wound or/and severe nipple pain	7 (15)	7(15)
-inverted, flat nipple	16 (32)	24 (51)
-previous breast reduction	3 (6)	3 (6)

<sup>1)</sup> Some mothers had more than one types of anaesthesia

**Table 8b.** Infant data collected from medical records

	Experiment group n=53	Control group n=50
Gestational age (weeks) Md (range)	39(34-42)	39 (34-41)
Birth weight (g) Md (range)	3460 (2130-4790)	3500 (2070-4490)
Gender, No (%)		
Female	29 (55)	27 (54)
Male	24 (45)	23 (46)
Healthy full-term, apgar >7 at 5 min	38 (78)	40 (85)
Full-term, apgar ≤7 at 5 min	4 (8)	0 (0)
Healthy premature ≤ week 37 apgar >7 at 5 min	7 (14)	6 (13)
Premature ≤ week 37 apgar <7 at 5 min	0 (0)	1 (2)
Infant cared for in the neonatal ward	10 (20)	3 (6)
<b>Complications first days post partum <sup>1)</sup></b>		
Hypoglycemia	14 (27)	14 (29)
Jaundice	11 (22)	12 (24)
Weight loss ≤10%	8 (16)	8 (16)
Blocked/obstructed nose/ breathing	2 (4)	3 (6)
Swollen tongue	1 (2)	0 (0)
Occasional vomiting first days	19 (44)	13 (31)
Ankyloglossia	0 (0)	2 (4)

<sup>1)</sup> Some infants had more than one complication

**Table 9.** Caring routines and interventions after birth

	Experiment group n=53 No. (%)	Control group n=50 No. (%)
<b>Variables</b>		
Oxygen post partum post partum	14 (28)	10 (20)
Oral or gastric suction post partum	19 (39)	16 (34)
No separation first hour post partum	28 (55)	28 (58)
Breastfeeding attempt ≤2 hour post partum	16 (31)	19 (40)
<b>Supplementary feeding<sup>1</sup></b>		
..Formula	42 (84)	39 (78)
<b>Reason for supplement feeding</b>		
.. Medical reason	29 (58)	24 (48)
.. No reason given	13 (26)	15 (30)
<b>“Hands-on latch intervention” during hospital stay</b>		
..yes	43 (93)	44 (96)
..no	3 (7)	2 (4)

<sup>1</sup>Supplementation was given for Md (Q<sub>1,3</sub>)2 (0-4) days in the experimental group and for 2 (0-3) days in the control group. days

### *Entry in study*

There were no significant differences between the age of the infants at trial entry, in the experiment group the infants were Md (Q<sub>1,3</sub>) 3.0 (2,0-6,2) and in the control group 2.7 (1,7-4,3) weeks old. Data on the breastfeeding situation at entry to the study is shown in Table 10.

**Table 10.** Data on mothers and infants at the time of entering the study.

	Experimental group	Control group
<b>Infants</b>		
Age of the child (weeks) Md (Q <sub>1,3</sub> )	3.0 (2,0-6,2)	2.7 (1,7-4,3)
<b><i>Latching and suckling ability according to the mothers</i></b>	<b>No.(%)</b>	<b>No.(%)</b>
-No latching or suckling at all	34 (64)	29 (58)
-Superficially latching without or with nipple shield	17 (32)	17(34)
-Latching only on one breast	2 (4)	4 (8)
<b><i>Nutrition</i></b>		
-Only breast milk (expressed)	18 (37)	18 (36)
-Breast milk (expressed) and supplement	31 (63)	32 (64)
<b><i>Supplement/breast milk given by:</i></b>		
-Bottle	42 (79)	34 (68)
-Alternatives methods		
-cup	7 (13)	10 (20)
-similar to cup	1 (2)	2 (4)
-only though nipple shield	2 (4)	4 (8)
<b><i>Use of pacifier</i></b>	18 (40)	12 (32)
<b>Mothers</b>		
<b><i>Mothers intended to breastfeed</i></b>		
- Less than 6 months	3 (8)	4 (10)
- 6 months	10 (26)	17 (41)
- More than 6 months	25 (66)	20 (49)

***Breastfeeding emotional scale***

There were no significant differences between the experimental and control groups in mothers' mean score on the Breastfeeding Emotional Scale administered before the screening breastfeed session (mean 58, SE 1.850 vs. mean 56, SE 2.232, p-value = 0.470).

However, the mean score on the Breastfeeding Emotional Scale assessed during the breastfeeding session after intervention was significantly higher in

the experimental group than in the control group (mean 69, SE 1.680 vs. mean 62, SE 2.443, p-value = 0.022).

#### *Breastfeeding Physical Pain Scale*

There were no significant differences between the experimental and control groups on the mothers' scoring on the Breastfeeding Pain Scale administered before the screening breastfeed session median 1.0 ( $Q_1 = 1.0 - Q_3 = 4.8$ ) vs. median 1.0 ( $Q_1 = 1.0 - Q_3 = 4.0$ ) p-value = 0.540. However, during the breastfeeding session after intervention the mothers in the experimental group scored significantly lower on the Breastfeeding Pain Scale, median 1.0 ( $Q_1 = 1.0 - Q_3 = 1.0$ ) vs. median 1.0 ( $Q_1 = 1.0 - Q_3 = 2.0$ ) p=0.0435.

#### *Proportions of infants starting regular latching-on and suckling*

The proportion of infants starting to latch-on and suckle did not differ significantly between the experimental group 75% (n=40), and control group 86 % (n=43) (Fisher's Exact test p-value 0.217).

#### *Time from intervention to regular latching and suckling*

For different reasons 9 mothers in the experimental group and 10 in the control group could not tell the time lapse between intervention and regular latching (see Figure 2). The 31 infants in the experimental group with registered time began latching on in a significantly shorter median time than the 33 infants with registered time in the control group, 2 weeks ( $Q_1 = 1.0, Q_3 = 3.7$ ) vs. 4.7 weeks ( $Q_1 = 2.0, Q_3 = 8.0$ ), (p-value = 0.020).

The number of weeks the infants with registered time spent from the intervention to regular latching and suckling is shown in (Figure 17).

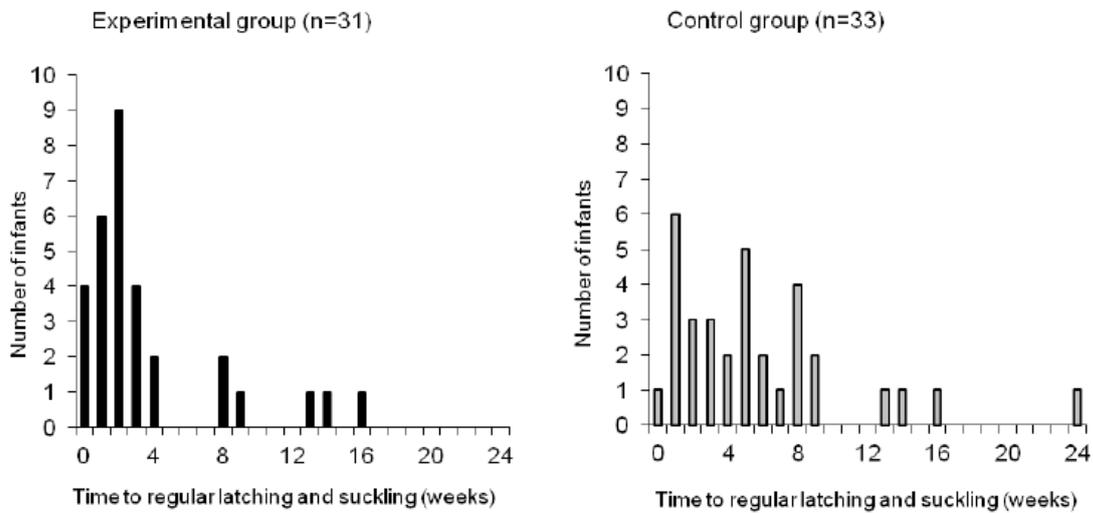


Fig. 18. Number of infants (regardless of age) in relation to number of weeks the infants spent from randomization to regular latching and suckling.

It was found that 23 infants out of the 31 (74%) of the registered infants in the experimental group started to latch regularly and suckle within three weeks versus 13 infants out of the 33 (39%) in the control group ( $p = 0.006$ ). It was found that in the experimental group 94% of those infants starting to latch-on regularly and suckle within three weeks had a history of “strong reaction” during “hands-on latch intervention” compared to 33% of the infants with “strong reaction” in the control group who started to latch-on within 3 weeks ( $p = 0.0001$ ). Similar amount of infants in the experimental and control group had shown “strong reaction” to the “hands-on latch intervention” (Table 11). Mothers’ experience to the “hands-on latch intervention” is shown in Table 12.

**Table 11.** Examples of expressions used by mothers to describe of the infant's reaction on "hands-on latch intervention"

<i>Mothers descriptions of infants reaction on "hands-on"</i>	<i>Number of infants</i>	
	<i>Total</i>	<i>exp/cont</i>
<b>Suckled temporarily</b>	1	0/1
<b>Passive reaction</b> "no reaction" "passive" "fell asleep" "didn't care" "not interested" "bored" "turned off"	20	11/9
<b>Strong reaction</b> "screaming" "became hysterical" "was defensive" "avoidant" "sad" "panicked" "worried" "mad" "angry"	62	30/32
<b>Did not receive hands-on intervention</b>	5	3/2
<b>Not noted</b>	15	9/6
<b>Total</b>	103	53/50

**Table 12.** Mothers experience of "hands-on latch intervention" during hospital stay

<i>Mothers experience of "hands-on"</i>	<i>Number of mothers</i>	
	<i>Total</i>	<i>exp/cont</i>
<b>Did not receive "hands-on"</b>	5	3/2
<b>"Hands-on" not hard:</b> "not painful" "I didn't know anything else" "unpleasant" "stressful".	38	19/19
<b>"Hands-on" hard:</b> "squeeze and pulling hard" "painful" "violent" "humiliating" "forceful" "heavy handed" "lasting bruises"	49	24/25
<b>Not noted</b>	11	7/4
<b>Total</b>	103	53/50

*Infants age in relation to time for regular latching and suckling*

To illustrate if age of the infants at inclusion was related to time it took to establish regular latching and suckling a simple regression analyses was performed. It was found that in the control group the infant age at inclusion correlated positively and significantly with the time it took to establish regular suckling ( $R = 0.409$ ,  $p = 0.018$ ,  $R^2 = 0.167$ ) in the experimental group there was

no significant correlation ( $R = 0.192$ ,  $p = 0.300$ ,  $R^2 = 0.037$ ). Thus, in the control group the infant's age at suckling was negatively influenced by its age at inclusion in the study. In contrast, in the skin-to-skin group, age at inclusion did not influence the time lapse between inclusion and suckling.

#### *Number of skin-to-skin contacts in relation to time for regular latching and suckling*

The median number of skin-to-skin contacts between mother and infant in the experimental group during the first 7 days after the intervention was 8.5 ( $Q_1 = 3$ ,  $Q_3 = 14.5$ ) times.

To understand if the number of skin-to-skin contacts affected the time it took to establish regular latching and suckling a simple regression analyses was performed. It was found that the number of skin-to-skin contacts did not correlate significantly with time elapsing from intervention to the time infants started to regularly latching and suckling ( $R = 0.158$ ,  $R^2 = 0.025$ ,  $p = 0.4720$ ).

#### *Mother's response to infant's regular latching and suckling*

Unexpectedly, 4 mothers in the experimental group and 8 in the control group stopped breastfeeding when the infants started regular latching and suckling. None of these mothers gave expressed breast milk thereafter.

Sixty-three percent (25/40) in the experimental group whose infant started to latch-on and suckle started to breastfeed exclusively compare to 58% (25/43) of the mothers in the control group (NS).

Among mothers whose infants did not latch-on at all, 11 in the experimental group and 4 in the control group continued to express breast milk and fed the infant by bottle.

#### *Four months follow up after inclusion*

Among mothers who had infants that started latching-on and suckling regularly 73% ( $n = 29$ ) in the experimental group and 63% ( $n = 27$ ) in the control group were still breastfeeding four month after intervention (NS).

The median age of the infants when starting latching-on and suckling regularly was 7.7 weeks, ( $Q_1 = 3.7$ ,  $Q_3 = 10.7$ ) in the experimental group vs. 7.1 weeks, ( $Q_1 = 4.6$ ,  $Q_3 = 11.7$ ) in the control group. This difference was not significant ( $p$ -value = 0.919).

At four months after inclusion mothers who were still breastfeeding filled in the Breastfeeding Emotional Scale once more before and during breastfeeding. For different reasons seven of the breastfeeding mothers in each group did not have the opportunity to fill in the scale, (see Figure 2).

With regards to the mean scale scores, there were no significant differences between the experimental group, (n=21) and the control group (n=20) neither before (73, SE 2.054 vs. 75, SE 2.731) nor during breastfeeding (72 SE, 2.656 vs. 75 SE) 4 months after inclusion.

*In summary*

Mothers in the skin-to-skin group who succeeded in starting to breastfeed were relieved from the stress of having a breastfeeding problem twice as quickly as mothers in the control group.

The stress of being forced to the breast was possibly one of the major contributing factors to the infant's latching-on problem. Interestingly to note is that the infants who had a history of "strong reaction" to stressful "hands-on latch intervention" were those restoring the biological breastfeeding program most rapidly in the skin-to-skin group. The skin-to-skin contact may have decreased the stress and induced a therapeutic relaxation in both mother and infant during which the infant was able to restore the biological program of breastfeeding behavior. Furthermore, mothers in the skin-to-skin group rated more positively on the Breastfeeding Emotional Scale during the breastfeeding session after intervention with skin-to-skin, than did the control mothers.

## 6 DISCUSSION

### 6.1.1 Main results in this thesis

In the present study we have investigated effects of skin-to-skin contact on parents' and infants' behaviour after an elective caesarean section and as a method to solve latch-on breastfeeding problems, in mother-infant dyads even months after birth.

The skin-to-skin contact showed immediate and prolonged effects. Both father-infant and mother-infant interaction induced immediate anti-stress effects, displayed by decreased infant crying in skin-to-skin contact with fathers (I-II), accelerated occurrence of the first breastfeeding in newborns with uninterrupted skin-to-skin contact with mothers after cesarean section (II-III) Mothers with latch-on problems had a more positive breastfeeding experience after the intervention with skin-to-skin contact according to the Breastfeeding Emotional Scale (IV) indicating calmness and contentedness. In addition increased tactile touch and vocal communication directed between the parents and to the newborn infant were identified (I-II). The skin-to-skin contact produced the onset of the newborns soliciting at an age of 15 minutes and triggered parental soliciting responses (I). A schematic illustration of the parent-infant communication interaction loop is shown in Fig. 18.

There was no significant effect of skin-to-skin contact on parental oxytocin levels. In contrast, both mothers and fathers showed an increase in plasma oxytocin levels lasting for 60 minutes. It was shown that mothers with oxytocin infusion had significantly higher oxytocin levels during skin-to-skin contact, when compared to skin-to-skin mothers without oxytocin infusion. Surprisingly, no such effects were seen in control mothers with or without oxytocin infusion.

Mother-infant skin-to-skin contact and oxytocin infusion induced a prolonged effect displayed two days post partum, shown in differences in KSP personality profile related to the specific intervention and treatment immediately during birth with cesarean section and two hours post partum. The most important findings were the low scores on detachment for all mothers except the control mothers without oxytocin and the low scores on somatic anxiety in control mothers with oxytocin infusion when compared to all the other groups (III). Infants with severe latch-on breastfeeding problems started to latch-on and suckle earlier in the skin-to-skin contact group (IV).

### 6.1.2 Effects of parent-infant skin-to-skin contact

#### *Infants' crying behaviour*

A new and somewhat surprising finding was that the infants cried more when in skin-to-skin contact with their mothers after cesarean section than with their fathers.

As mentioned in the introduction natural maternal breast odors reduce crying (Doucet, Soussignan et al. 2007) and elicit approach behavior in newborns (Varendi and Porter 2001), whereas unpleasant odors induce avoidant behavior. Girls were shown to cry more than boys, especially when in skin-to-skin contact with their mothers. One possible reason could be that the newborn girls reacted more than boys to the unnatural and unpleasant smell of chlorhexidine used to disinfect the mother's breast, as girls are more sensitive to olfactory cues (Varendi, Porter et al. 1997).

The infant's increased crying in skin-to-skin contact with mothers might also be related to maternal hypothermia due to the spinal anesthesia in connection with the cesarean section (Christensson, Siles et al. 1993; Saito, Sessler et al. 1998; Ransjo-Arvidson, Matthiesen et al. 2001) making it difficult for the mother to keep the newborn warm. Another possible reason could be that the parents' differential position and behaviour towards boys and girls influenced the newborns' reaction. The fathers' upright position might have facilitated the newborns breathing capacity, which might lead to a reduction in crying (Erlandsson 2008) compared to the mothers supine position during surgery. Infants in skin-to-skin contact with their fathers shifted to a relaxed state earlier than infants in skin-to-skin contact with mothers. Since fathers were not exposed to any medical intervention, they had presumably retained their natural capacity to calm the infant, by warmth, pleasant odors, and vocalizations and thereby reduced the crying of the infant. The skin-to-skin contact between fathers and newborns might thus have been an essential sensory stimulation leading to increased father-infant vocal interaction.

During the father-infant skin-to-skin contact the paternal behaviours such as soliciting, kissing and touching the infant might also be induced already by the sight of the newborn and the perception of the newborn's odor in the same way as it has been shown to induce maternal behaviors (Fleming, Corter et al. 1993; Levy and Keller 2009).

### *Parents influence on infants soliciting*

The main findings were that an additional component of the inborn prefeeding behavior were identified. That is, vocal interaction with the parents', crying, whining, speech, and soliciting, which all occurred in a specific order.

After the newborn's birth cry, which lasted for approximately 1 minute, the parents started to interact vocally with their newborn infant. Both mothers and fathers in skin-to-skin contact displayed more vocal interaction than parents without skin-to-skin contact. The fathers' and mothers' speech to their infants increased significantly and so did fathers' speech to mothers. Indeed, vocalization has been suggested to be as important as touch in the activation of neuroendocrine mechanisms involved in the regulation of social bonding in humans (Seltzer, Ziegler et al. 2010). The fact that the control fathers showed significantly less vocal interaction suggests that holding the infant in skin-to-skin contact elicits intuitive parenting behaviors, in a supportive environment.

Infant initiated communication with soliciting sounds with the parents when placed in skin-to-skin contact at approximately 15 minutes of age. Infants' soliciting occurred after hearing the parents' speech. This interactive prefeeding behavior probably activates speech motor areas in the newborns (Gentilucci and Dalla Volta 2008), and the soliciting may be an expression of imitation of the parents' vocal communication (DeCasper and Fifer 1980; Ockleford, Vince et al. 1988). Recently, this imitation has been attributed to activation of mirror neurons (Lepage and Theoret 2007). The communication with soliciting sounds occurred in most infants and also in some parents. Mirror neurons might also be activated in the parents (Carr, Iacoboni et al. 2003) during this first interaction with soliciting sounds.

The meaning of the infant's vocal solicitation might be to attract the parent's attention. The infant can also distinguish between the voice of the mother and other voices (Lagercrantz 2009).

Interestingly, in five families no soliciting occurred during the observation period either from the infants or from the parents. Presumably, these infants did not perceive their parents' voices or did not receive the right cues to be able to initiate soliciting calls. Taken together, our results demonstrate that exposure to skin-to-skin contact after birth may facilitate the communicative aspect and the receiving aspect of vocal interaction between parents and infants.

### *Mothers and fathers interactive style with their newborn infant*

The most important finding was that paternal interaction was improved by skin-to-skin contact regardless of the sex of the infant (II).

Both mothers and fathers showed spontaneous affectionate feelings; they smiled and kissed the newborn. These types of behaviours may play a role in the formation of bonding and attachment between parents and their infants and vice versa.

Mothers in skin-to-skin contact touched their newborn boys significantly more than they touched their girls. One reason for mothers increased engagement in newborn boys might be their higher testosterone levels when compared to girls (Gitau, Adams et al. 2005). Testosterone has been suggested to influence the mothers' interactive (grooming) behaviour in mammals (Wallen, Maestripieri et al. 1995).

Indeed, the different maternal behaviours towards boys and girls shown in paper (II) are consistent with studies on maternal behavior in rats showing that maternal touching behavior was sexually dimorphic, with male offsprings receiving more touch than female offsprings during the neonatal period (Kurian, Olesen et al. 2010). Fathers in skin-to-skin contact with their newborns directed significantly more speech towards their newborn boys than they did towards their newborn girls.

The differences observed in the type of interaction with the newborn expressed by mothers and fathers and also the modification of parental behaviour by the sex of the newborn may in part represent inborn sex specific responses in mothers and fathers (Moffatt 2003) and in addition may be a culturally and socially learned behavior.

### *Newborns breastfeeding behaviour*

The main findings were that girls showed enhanced breast-seeking behaviour and that uninterrupted mother-infant skin-to-skin contact for the first 30 minutes after birth accelerated the appearance of the first breastfeeding(II).

Newborn girls rooted and performed breast-massaging movements earlier than boys irrespective of being in skin-to-skin contact with mothers or fathers. This finding is in line with previous observations showing that female fetuses and newborn girls perform more mouth movements, (often associated with rooting movements and sucking) than boys (Korner 1973; Hepper, Shannon et al. 1997; Bell, White-Traut et al. 2010). The girls' enhanced breast-seeking behaviour might also be related to, enhanced self-regulation in female infants (Lundqvist and Sabel 2000; Boatella-Costa, Costas-Moragas et al. 2007) and females' preference of faces and face recognition (Connellan 2000; Rehnman and Herlitz 2006; Rehnman and Herlitz 2007).

Such inborn behavioural differences have been attributed to differential actions by the sex steroids estrogen and or testosterone on the fetal brain. It has for example been shown that the greater fine motor skills and the enhanced sensory sensitivity (Bell and Costello 1964; Varendi, Porter et al. 1997) are linked to prenatally induced effects of estrogen (McEwen 2001).

Infants' first breastfeeding appeared significantly earlier when the newborns had been in skin- to-skin contact with the mother than with the father. Indeed, an oxytocin peak at approximately 75 minutes was observed, but it was only significant in the skin-to-skin contact mothers with oxytocin infusion. It has been shown that the unmedicated newborn infant makes itself familiar with the nipple and areola by licking and touching of the areola and nipple before onset of suckling (Widstrom, Lilja et al. 2011). These behaviours are likely to prepare the mother to give out milk by enhancing her oxytocin release (Matthiesen, Ransjo-Arvidson et al. 2001). In this study breastfeeding occurred at about 80 minutes in half of the infants. Presumably the newborns early olfactory learning in skin-to-skin contact with the mother, might have facilitated the newborns' familiarization and recognition of the mother's breast (Wilson and Sullivan 1994), despite of their increased crying reaction.

Taken together, uninterrupted skin-to-skin contact with the mother accelerated the first breastfeed after caesarean section in this study (II-III) compared to the infants in the control group who were separated from their mother for 25 minutes, being in skin-to-skin contact with the father.

### *Release of oxytocin*

#### *Mothers*

Mothers showed an increase in oxytocin levels over time for the first 60 minutes after an elective Caesarean birth, with the highest oxytocin levels in skin-to-skin contact mothers having had an oxytocin infusion.

In a previous study performed on women after vaginal delivery a transient rise of oxytocin levels were observed in mothers being in skin-to-skin contact with the newborn. The rise of oxytocin levels was 46 pM and the duration of the rise was 45-60 minutes (Nissen et al 1995). The rise coincided with expulsion of the placenta. Whether the rise of oxytocin levels was actually due to the skin to skin contact or occurs automatically in order to deliver the placenta is not known, but the amount of infant's

hand massage and suckling is quantitatively linked to the rise of oxytocin levels (Matthiesen et al 2001).

In the present study (III), the mothers who did not receive an oxytocin infusion exhibited a post partum rise in oxytocin levels equal to the rise reported in a previous study performed in women after a vaginal delivery (Nissen, Lilja et al. 1995). There was however no difference between mothers in the skin-to-skin and the control group, suggesting that other factors than skin-to-skin contact might be responsible for the rise. The blunted oxytocin release pattern in the skin-to-skin mothers may be a result of the increased crying in infants skin-to-skin with mothers (paper I), suggesting that the infants' screaming stressed the mothers (Clarici, Travan et al. 2002) and hampered their oxytocin release (Newton and Newton 1948).

The infants in the control group who were in skin-to-skin contact with their fathers cried much less. This indicates that other auditory, visual and olfactory cues might have contributed to the oxytocin rise observed at 20 minutes in the control mothers group, as sensory cues have been linked to a release of oxytocin (McNeilly, Robinson et al. 1983) (Strathearn, Fonagy et al. 2009); and also in response to the social vocalizations (Seltzer, Ziegler et al.).

Another explanation could be that the rise of oxytocin can be due to the stressful experiences as a consequence of the caesarean section and the unfamiliar surroundings in the operation theater. It may even be caused by an inborn oxytocin release, aimed at delivering the placenta.

A significant rise in oxytocin levels was, however, observed in mothers having skin-to-skin contact with their infants after birth with caesarean section, if they received an infusion of oxytocin (50 IU) during the postpartal period.

The finding that the mothers without oxytocin infusion did not differ significantly between mothers with or without skin-to-skin contact in regard to oxytocin release in the present study may also be related to the type of birth they had undergone. Since the lack of labor and the effects of the spinal anaesthesia might reduce the oxytocin release (Nissen, Uvnas-Moberg et al. 1996; Rahm, Hallgren et al. 2002). The infusion of oxytocin may have substituted for the release of oxytocin, normally occurring during labor.

In addition the spinal anesthesia may have contributed to the blunting of oxytocin release in response to skin to skin contact, as it has been shown that administration of local anesthetics during labor has been associated with a decreased interaction and slowed interaction between mother and infant and also a decreased sensitivity to sensory stimuli as less oxytocin was released in response to infant's hand massage than in mothers who had not received local anesthetics (Matthiesen et al to be published). Interestingly oxytocin was released during the period of skin-to-skin contact in mothers who had received a simultaneous infusion of oxytocin. The oxytocin infusions per se did not raise oxytocin levels, as there was no difference in oxytocin levels in control mothers having received oxytocin or not during the 2 hour observation period. It was surprising that infusions of 50 IU of oxytocin (corresponding 41.5 microgram) did not cause an elevation of oxytocin levels. The duration of the infusion averaged 114 minutes, and therefore the infusion rate was 0.36 microgram/minute. As the half-life of oxytocin is 1-2 minutes an elevation of oxytocin levels should be expected. Oxytocin levels have been measured in response to infusion of oxytocin. In these studies, which were performed on men, oxytocin levels rose significantly as measured by RIA (Legros, Chiodera et al. 1988). Why a rise of oxytocin level was not observed in response 0.36 micrograms/minute is not known. The half-life for oxytocin in plasma is 1-2 minutes, but might be shorter just after birth as oxytocin as the metabolism of oxytocin in the liver and in the kidneys is further enhanced by placental oxytocinase, which may still be present in the circulation immediately after birth. Still, clear elevations of oxytocin levels were observed when the mothers had received oxytocin and skin-to-skin contact. These data indicate that infused oxytocin induced a feed forward effect on oxytocin release into the circulation. In a recent study oxytocin infusion during labor were shown to decrease anxiety levels and to increase social interaction (Jonas, Nissen et al. 2008). Oxytocin administered peripherally is only thought to cross the blood-brain barrier at approximately 1% (Ermisch, Barth et al. 1985). Therefore, due to its chemical characteristic, the effect must have been induced in the periphery. Possibly oxytocin acts by increasing the activity in peripheral sensory nerves e.g. originating in the skin (Olausson, Cole et al. 2008), which in turn stimulate the release of oxytocin via actions in the brain. Interestingly a feed forward mechanism for oxytocin release has been demonstrated at the level of the oxytocin producing cells in the hypothalamus, as administration of oxytocin increases the release of oxytocin (Freund-Mercier and Richard 1981; Freund-

Mercier and Richard 1984; Moos, Freund-Mercier et al. 1984; Freund-Mercier and Stoeckel 1995).

Interestingly oxytocin levels rose in response to breastfeeding in mothers who received infusion of oxytocin, irrespective of belonging to the skin-to-skin group or the control group. No effect on oxytocin levels was observed in response to breastfeeding in the absence of oxytocin infusion. These results also support the idea that oxytocin infusion facilitates oxytocin release in response to sensory stimulation in the former case induced by skin-to-skin contact and in the case by the suckling stimulus.

The rise in circulating oxytocin levels observed after birth in the mothers having had a Caesarean Section may have been reflected by a rise of oxytocin levels in the brain, as has been demonstrated to occur in ewes (Keverne and Kendrick 1994; Kendrick 2000; Poindron 2005). Therefore the rise of peripheral oxytocin levels observed in the mothers may indicate that also mothers having had a caesarean section may have a sensitive period, during which long term adaptations which facilitate future interaction with the infant may be induced.

### *Fathers*

Oxytocin levels in the fathers did not show a clear response to skin-to-skin contact. However, a small but significant increase in oxytocin levels was seen during the first 60 minutes post partum in both the skin-to-skin and the control group, suggesting that being present at birth may enhance oxytocin release (Ebisch, Perrucci et al. 2008). In addition some significant differences in oxytocin levels were demonstrated at specific time points. In fact, the control fathers exhibited an increase oxytocin level at 20 minutes, suggesting that just being close to the baby and its mother, watching the mother touch the baby may enhance oxytocin release (Ebisch, Perrucci et al. 2008). Indeed, looking at pictures of significant others has also been shown to activate regions in the brain that keep high densities of oxytocin receptors, indicating oxytocin activity (Bartels and Zeki 2004).

Fathers may also increase their oxytocin levels in response to infants' cry as has been shown in mothers (McNeilly, Robinson et al. 1983) and during social vocalization (Seltzer, Ziegler et al. 2010).

Previous findings (paper I), based on the same research project as this one, showed that fathers in skin-to-skin contact with the newborn smile more, kiss more (Velandia, Uvnas-Moberg et al. 2011) and speak more to their newborns and to their partners

(Velandia, Matthisen et al. 2010), behaviours that may well correspond to the oxytocin release pattern.

A distinct peak of oxytocin levels was observed in the skin-to-skin fathers at 35 minutes. Interestingly, this time point coincides with the time the infants were transferred from the fathers to the mothers. Separating the infant from the father may stress the father, resulting in a rise in oxytocin.

### *Differences in personality traits in mothers*

When the personality profile was compared to the normative group, both the control group and the skin-to-skin contact group scored lower on psychic anxiety, psychoasthenia, inhibition of aggression, detachment and guilt indicating a personality profile of wellbeing (Uvnäs-Moberg K 1990; Nissen, Gustavsson et al. 1998; Sjogren, Widstrom et al. 2000).

The results suggest that the mothers in our study are calmer and feel less detached two days after childbirth when compared with the normative group.

Skin-to-skin mothers, regardless of oxytocin infusion, scored higher on monotony avoidance and indirect aggression than the normative group. Monotony avoidance has been shown to decrease over the course of pregnancy (Sjogren, Widstrom et al. 2000) and breastfeeding women score lower on this scale in some studies (Uvnäs-Moberg K 1990; Sjogren, Widstrom et al. 2000), while in other studies, the scoring of monotony avoidance does not differ from the normative group (Nissen, Gustavsson et al. 1998; Jonas, Nissen et al. 2008). In the former studies, KSP was assessed four days or more than in the latter studies, where KSP was reported two days after birth. It is possible that the higher scores on the monotony avoidance and indirect aggression scales in skin-to-skin mothers correspond to a protective and vigilant behavioral pattern as part of early maternal adaptation (Hahn-Holbrook, Holt-Lunstad et al. 2011).

The mothers in the control group without oxytocin infusion scored lower on social desirability than the normative group. Social desirability has often been described as a wish to please (Smith and Ellingson 2002). In the context of maternal adaptation one interpretation would suggest that high scores on this scale corresponds to a more

sensitive response to the cues of the infant. If so, skin-to-skin contact may, in contrast to separation, enhance the development of maternal sensitivity.

The skin-to-skin contact mothers with and without oxytocin infusion and the control mothers with oxytocin-infusion showed lower scores on the detachment scale than control mothers without oxytocin infusion. This result suggests that oxytocin infusion enhances the effects of skin-to-skin contact on certain aspects of maternal adaptation. Indeed, a dose dependent relationship between detachment and oxytocin administered during labour has previously been shown in women delivered by the vaginal route (Jonas et al 2009). Low scores on detachment have previously been described as a need for close relationship (Wiklund, Edman et al. 2009), suggesting an open contact-seeking maternal behaviour directed to the infant.

No difference was found on the somatic anxiety scale between skin-to-skin mothers and control mothers without oxytocin infusion. In mothers having had an oxytocin infusion, somatic anxiety was significantly reduced in control mothers when compared to skin-to-skin mothers.

The increased levels of somatic anxiety in mothers having had both oxytocin infusion and skin-to-skin contact after birth, may be related to the physical trauma related to the Caesarean Section. It is possible that closeness after birth in addition to the surgical trauma increases somatic anxiety. The mothers, who have bonded to their newborn, may feel more vulnerable to somatic anxiety. It has been reported that mothers of premature infants who had experienced more eye contact and felt closer to their infants also perceived more anxiety, (Kleberg, Hellstrom-Westas et al. 2007).

#### *Breastfeeding latch-on problems*

The most important finding was that mother-infant dyads with latch-on and suckling problems treated with skin-to-skin contact, succeeded to establish proper breastfeeding two weeks earlier than control mother-infant dyads who only received professional guidance except counseling regarding skin-to-skin contact (IV). Skin-to-skin contact seems to be specifically beneficial to infants with a history of having reacted strongly to be attached to the breast with “hands-on latch intervention”. The skin-to-skin contact mothers showed an immediate rise in maternal feelings after the intervention, which could not be seen in mothers in the control group.

The majority of the participant mother-infant dyads who were included in the study had undergone above average rates of medical interventions in connection with birth, i.e. epidural anesthesia during labor, caesarian section, parent-infant separation after birth, “hands-on latch intervention” during breastfeeding bottle feeding as well as exposed to formula feeding when they entered the study. As mentioned in the introduction, many of the interventions the women had been exposed to are practices known to hamper exclusive breastfeeding.

All mothers in this study had been seeking help for the infants’ difficulty to latch-on to the breast at maternity wards, well baby clinics and breastfeeding out-patient clinics. Within one screening visit, the two investigators in this study solved the sucking problems in 127 of the 230 mother- infant pairs. This implies that the standardized model to guide mothers was remarkably well adapted to the mothers’ breastfeeding problems. The same standardized model for breastfeeding counselling was used in both the experimental and control group.

The stability of this model for breastfeeding counselling is supported by the fact that approximately the same number of infants started to suckle in both experimental and control groups, even when controlling for hospital/midwife. In addition to this standardized model for counselling, skin-to-skin contact between mother and infant added some important factors, as the infants in the skin-to-skin group started to suckle regularly after a significantly shorter median time than the infants in the control group.

#### *Infants’ reaction to skin-to-skin contact*

The infants in the skin-to-skin contact group succeeded to breastfeed earlier than the infants in the control group. They seemed to re-capitulate the inborn biological behaviour to find the mother’s breast by getting acquainted, freely moving, touching and licking on the mother’s breast and nipple (IV). This breast-seeking process is suggested to develop the infants’ rooting-tongue reflex.

This assertion is supported by a previous study showing that infants with uninterrupted mother-infant skin-to-skin contact for at least one hour after birth were sucking correctly compared to infants who had been separated for 20 minutes and then clothed and returned to the mother to breastfeed (Righard and Alade 1990). In addition, the results of the present study also show that with caesarean section, 25 minutes of early maternal-infant separation after birth delay the first breastfeeding after birth (II-III). Infants in the experimental group who had “reacted strongly”, during “hands-on latch intervention”, were those who started to suckle significantly earlier than the infants in

the control group who had “reacted strongly” from the “hands-on latch intervention”. The skin-to-skin contact with the mother may calm in the infant. Bystrova et al. (2003) have suggested that skin-to-skin early after birth decreases the negative effects of “the stress of being born” (Bystrova, Widstrom et al. 2003). It is likely that skin-to-skin contact with the mother even in these “older” infants will counteract “the stress of being forced to breastfeed”. This is supported by a recent study that infants staying skin to skin for more than 1 hour after birth had lower cortisol levels in saliva than infant staying less than 1 hour, indicating that skin to skin contact relieves stress and thus induces relaxation in the infant (Takahashi, Tamakoshi et al. 2011). Skin-to-skin contact may relieve the memory of stressful experiences for those infants who were forced to the breast. With skin-to-skin contact, the infant can relax, stop crying and maintain enough calm to successively, and successfully, co-ordinate body movements with its five senses (sight, touch, hearing, smell and taste); all essential to achieve the latch and suckle, echoing the patterns of a normal newborn’s prefeeding behaviour during the first hours of life (Widstrom, Lilja et al. 2011).

Interestingly, it has previously been found that infants who remained skin-to-skin with their mother one and a half hours after birth had more optimal self-regulation one year later than infants who were separated from their mothers and placed in the nursery during the same length of time (Bystrova, Ivanova et al. 2009). The skin-to-skin sessions with the mother seem to have helped the older infants to a more optimal self-regulation and breast-seeking behaviour. In contrast to the skin-to-skin infants, the infants in the control group, who were dressed and placed in front of the breast had less of an opportunity to freely latch-on to the breast. Presumably neither the infant nor the mother could fully relax in the control group in the same way as in a reclined position in skin-to-skin contact group. The mother’s stress may have affected the infant and the infant’s stress may also have been transferred to the mother.

#### *Mothers’ reaction to skin-to-skin contact*

Skin-to-skin contact may have exerted an anxiolytic-like effect on the mother, which may have contributed to reduce the time period before the infant could latch-on and suckle regularly. The skin-to-skin contact may cause an increase in oxytocin release followed by relaxation and subsequent milk let-down (Handlin, Jonas et al. 2009). Skin-to-skin mothers rated significantly higher on the Breastfeeding Emotional Scale and had thus a more positive response to breastfeeding during feeding than the control mothers. The results suggest that the mothers, as well as the infants, in the

experimental group were relaxed by skin-to-skin contact which might have facilitated the mothers let-down reflex and also have stimulated the infant to seek the breast (Varendi). In addition, the skin-to-skin mothers described significantly less pain during breastfeeding, which may have to do with the pain relieving effect of skin-to-skin contact as has been found in infants (Gray, Watt et al. 2000).

After four months, mothers in the control group had about the same level of positive emotional feelings on the emotional scale as the experimental group. Thus, the skin-to-skin contact with infant seems to have enhanced early maternal positive emotions towards breastfeeding.

### 6.1.3 Physiological and behavioural mechanisms

The studies in this thesis investigated the immediate and prolonged effects of parent-infant interaction in skin-to-skin contact and oxytocin infusions in mothers post partum. Both father-infant and mother-infant interaction induced immediate anti-stress effects, displayed by decreased infant crying in skin-to-skin contact with fathers (I-II) and accelerated occurrence of the first breastfeeding in newborns with uninterrupted skin-to-skin contact with mothers after cesarean section (II-III) (i.e. increased self-regulation). Corresponding anti-stress effects were seen in mothers with latch-on problems who reported higher on the breastfeeding emotional scale seen in the variables as calmness, confidence and contentedness already after the first skin-to-skin session (IV). Mother-infant skin-to-skin contact with and without oxytocin infusion, induced effects on maternal personality profile towards lower self reported anxiety and detachment in KSP personality inventory two days after childbirth (III). These immediate and prolonged effects are likely to be due to the oxytocin rise.

Approximately 1% of oxytocin administered peripherally passes through the blood brain barrier (Ermisch, Ruhle et al. 1985). The mothers who had received infusion of oxytocin had received a 5 fold physiological dosis of oxytocin. The oxytocin infusion might have had both a peripheral and central effect in skin-to-skin contact mothers as shown in higher plasma levels and adjustments in personality scores towards a more sensitive maternal behavior, measured by the Karolinska personality scale two days post partum. The mothers' oxytocin rise observed in this study after birth, seems to increase the oxytocin receptors. Despite the spinal block, which may result in reduced sensitivity in the skin (Skarp A, unpublished data.), the peripheral oxytocin infusion

and the skin-to-skin contact may induce sensitive activation of the sensory nerves in the mothers' chest above the level of administration and trigger neuroendocrine responses. The oxytocin infusion may cause an increase in regulation of the oxytocin receptor system which might partly be influenced by the placental hormonal withdrawals such as reduction of progesterone release post partum and or the sensory stimulation during the mother-infant interaction. It has previously been found that progesterone inhibits the formation of oxytocin receptors in the uterus of other mammals (Nissenson, Fluoret et al. 1978; Fuchs, Periyasamy et al. 1983; Fuchs, Periyasamy et al. 1983). The hormonal change at birth may therefore also in human mothers influence the oxytocin receptor system, especially post partum when the progesterone levels decreases.

#### 6.1.4 Sensitive period

During the first hour after birth a cascade of interactive behaviours evolve and the oxytocin levels in mothers and fathers in close contact with the infant show an elevation which returns to basal levels approximately one hour after birth. The rise of oxytocin coinciding with close interaction was stronger in skin-to-skin parents, suggesting that oxytocin may play a role in developing parental sensitivity to the newborn. In this study (paper I-II), the parents' presence at birth and the immediate post partum period activate their sensory systems as reflected in increased oxytocin release (Uvnas-Moberg 1998; Ditzen, Schaer et al. 2009; Lee, Macbeth et al. 2009). The oxytocin release observed in this study may well induce a sensitive period when the parents are likely to form strong bonds to their infant. The concept of a sensitive period, very soon after delivery is not only supported in animal studies but also in human studies (Klaus, Jerauld et al. 1972; Kennell, Trause et al. 1975; Klaus 1975; De Chateau and Wiberg 1977; De Chateau and Wiberg 1977; Widstrom, Wahlberg et al. 1990; Bystrova, Ivanova et al. 2009).

The interactive effects observed in parents and their infants during skin-to-skin contact may in part be caused by the activation of sensory nerves (Olausson, Cole et al. 2008) (Loken, Wessberg et al. 2009) and a subsequent release of oxytocin. Activation of sensory nerves via skin-to-skin contact may therefore stimulate oxytocin release in brain areas involved in the control of different aspects of social interactive behaviour. This maybe be done by increasing the parental responsiveness to infant cues (Heinrichs and Domes 2008), by reinforcing the sensory capacity of the auditory system and by activating areas in the brain involved in speech production. This interpretation is

supported by the findings that oxytocin administered as nasal spray in humans has been demonstrated to stimulate pro-social behaviour, increase eye gaze and to increase the sensitivity to sensory cues (Heinrichs, von Dawans et al. 2009). Also other sensory cues such as visual, auditory and olfactory cues contribute to the activation of oxytocin release and oxytocin mediated effects (Uvnas-Moberg 1998; Seltzer, Ziegler et al. 2010). In addition, our results suggest that oxytocin infusion enhances the effects of skin-to-skin contact on certain aspects of maternal adaptation after caesarean section.

#### **6.1.5 The significance of vocal interaction and breastfeeding**

We have found that the skin-to-skin contact promotes parent-infant interaction (paper I-II), makes the mother sensitive to the infants soliciting cues and probably attracts the mother's attention to have eye contact and communicate with the infant. The mother-infant skin-to-skin contact also seems to have helped the mother and her infant overcome the latch-on problems (IV).

The vocal parent-infant interaction that appears approximately 15 minutes after birth during skin-to-skin contact, seems to make the parents sensitive to the infant's cues as part of a process of the breast-seeking and breastfeeding behavior. Soliciting is known to increase as the infant approaches the breast after having exhibited mouth-breast hand movements to get the smell and taste of the nipple (Widström et al. 2011). This so called familiarization phase has been shown to be of great importance for successful suckling and during this phase the mothers in this study exhibited a corresponding elevation in oxytocin. During breast-seeking behavior the infant uses fine motor skills to coordinate the prefeeding movements, this behaviour seems also to activate speech motor areas in the newborn brain.

The early vocal interaction in skin-to-skin contact might also influence feeding behaviour in the long-term perspective (Wilson, Saygin et al. 2004; Imada, Zhang et al. 2006) (Kleberg, Westrup et al. 2000).

Our result suggests that even the parent-infant vocal interaction in uninterrupted skin-to-skin contact with the mother contributes to the point-in-time for first suckling. It is therefore very important to form a permissive setting where the parents feel free to interact with the infant without disturbing caring routines. The interaction is to be considered as a specific phase in the breast seeking behavior. When acknowledged, this will prevent heavy handed interventions to try to make the baby latch-on.

These described mechanisms of skin-to-skin contact with the infants' biological breast-seeking behaviour and parent-infant interaction may explain why the process of initiating successful latch-on and why breastfeeding is accelerated by the mother-infant skin-to-skin contact shown in this thesis.

## 6.2 METHODOLOGICAL CONSIDERATIONS

*Sample size.* In paper I-III a small sample size was planned. To be able to draw conclusions, strict inclusion criteria limiting variance in background, obstetrical data, infant status and birth weight were used. Reducing the variation in background variables to control the influence of potentially confounding variables in a randomized trial prior to randomization strengthens the result when the sample is small. Of course using such strict inclusion criteria, leads to reduced generalizability of the results. Additionally, all comparisons were planned and no post hoc comparisons were made. Some results did not reach statistical significant differences, probably due to a too small sample size, even though the results pointed in the same direction as in previous studies (Korner 1973; Hepper, Shannon et al. 1997). In the present study, due to the small sample size and a nonparametric distribution of certain variables, nonparametric statistical analysis has been performed. It is suggested that this is a hypothesis-generating study, as a part of the research process and larger studies are needed. In paper III, even sub group analysis had to be done due to the unexpected frequent use of large doses of oxytocin. The results must therefore be interpreted with caution and further studies are needed to corroborate the findings. (III)

*Reliability of observations.* It is well known that an observer changes her observations over time due to experience. In paper I and II, an inter-rater reliability test of the observations was shown to be satisfactory. It should be stated, however, that the setting, an operation theatre, is not optimal for parent-infant interaction, since the behavior under study might have been disturbed by the activities in the operation theatre. The observer was, for natural reasons, not blind to the skin-to-skin-contact intervention but was not otherwise involved in, or informed about, the specific aim of the study. The vocalizations recorded were well defined, and little was left to personal assessment, which diminishes observer bias. In the noisy setting of the operation theater, watching

the newborn on videotapes helped the observer disentangle the infant's vocalization from surrounding noise.

*Using two active treatments and no control group without treatment, paper I-III, lies in the risk of inter-treatment contamination. Oxytocin is known to be mediated by sensory stimulation which could cause contamination between the groups. If control mothers and control fathers had been separated from their families immediately after birth no such contamination of the controls would have occurred. This would however not be an ethically appropriate thing to do.*

*Considerations on internal missing.* In paper IV, 77% (64/83) of the mothers whose infants started regularly latching and suckling (31 in the experimental group and 33 in the control group) were able to specify the time in days/weeks for this event and 9 mothers in the experimental group and 10 mothers in the control group could not specify the exact time point when the infant started to latch-on and suckle regularly, which was the main outcome measure. There might be different reasons why these mothers could not specify the exact time point. Six of these mothers (3 in each group) continued using nipple shield making it more difficult to specify the exact time point. The remaining mothers (6 experimental mothers' vs. 7 control mothers) who could not specify the exact time point, might have found it more difficult to distinguish between irregular and regular latching and suckling while also focusing on bottle-feeding.

#### *Future studies*

Larger studies are needed to corroborate the findings of study I-III. Further long-term studies are needed to understand the effects of skin-to-skin contact on breastfeeding and infant development and health. Implementations studies are under way and evidence based guidelines are greatly needed to establish proper caring routines for mothers with traumatic childbirths.

## 7 CONCLUSIONS

I. When placed in skin-to-skin contact with either parent after a planned caesarean section, infants in skin-to-skin contact with fathers, cry less than infants in skin-to-skin contact with mothers.

Fathers and mothers in skin-to-skin contact are more open for vocal interaction than the parent without such contact. Newborn infants started to interact with soliciting sounds 15 minutes after birth.

Mothers show more tactile stimulation while fathers engage more in speech, in particular directed to the newborn boy. When in skin-to-skin contact, the fathers show more signs of affection towards and communicate more with their newborn than the mothers do.

Uninterrupted skin-to-skin contact with the mother accelerates the time point for the infants' first breastfeeding when compared to an interruption of skin-to-skin contact for as short time as 25 minutes when the baby is transferred to the father to be in skin-to-skin contact with him.

All mothers and fathers show significant rise in oxytocin levels during the first 60 minutes after the child was born. No significant difference was found between the parent having skin-to-skin contact or not. If high doses of oxytocin are administered to the mother post partum for medical reasons, maternal oxytocin levels are enhanced but only during in skin-to-skin contact.

Day two after child birth mothers reported low scores on anxiety variables with and without oxytocin or skin-to-skin contact. All mothers but controls reported low scores on detachment, which suggest an openness to form new bonds.

II. Skin-to-skin contact as a treatment for mother-infant dyads with severe latch-on problems was shown to restore their innate breastfeeding program and achieve satisfactory breastfeeding twice as quickly as the control group, even months after birth. Infants exposed to a history of "strong reaction" to stressful "hands-on latch intervention" were those restoring the biological breastfeeding program most rapidly.

Mothers in the skin-to-skin contact rated more positively on the Breastfeeding Emotional Scale than the control mothers with regards to items such as calmness, contentedness and confidence.

## 8 CLINICAL IMPLICATIONS

- I. Skin-to-skin contact should be recommended immediately after birth with a planned Caesarean section if there are no medical counter indications.

During the skin-to-skin contact with the mother, the new family should be encouraged to stay in close contact to enable parent-infant interaction during this period.

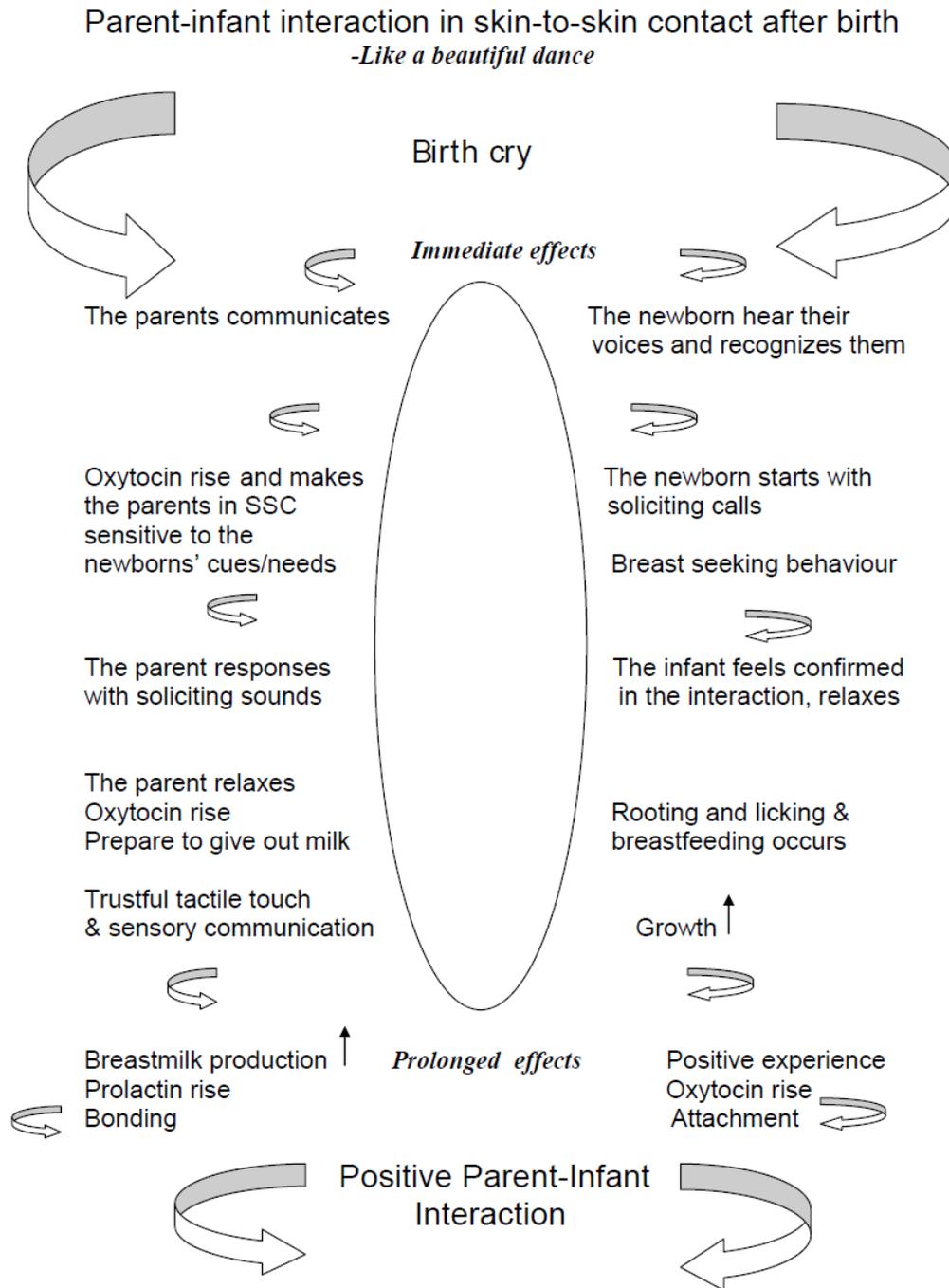
During this first meeting, the parent-infant vocal interaction should be recognized as a part of the infants prefeeding behaviour and the new family should not be interrupted by caring interventions such as talking; removing the infant to perform examinations or by any other practice that disturbs the family.

In case the mother is unable to provide skin-to-skin contact immediately after birth, the father is a valuable alternative, since skin-to-skin contact promotes his interaction with the newborn infant.

- II. Skin-to-skin intervention should be considered a choice of treatment to rectify long-lasting latch-on problems.

Latch-on problems may be prevented by skin-to-skin contact directly after birth up until the first breastfeeding, enabling the infant to develop its biological breastfeeding program and start its first suckling.

## 9 SCHEMATIC ILLUSTRATION



**Figure 18.**

The schematic illustration demonstrates the sensory communication and interaction during parent-infant skin-to-skin contact immediately after birth.

## 10 ACKNOWLEDGEMENTS

This thesis is a product of a long lasting collaboration and I wish to express my sincere gratitude to those who have supported me and made this thesis possible.

I gratefully thank all families that shared their experience with me.

I am sincerely grateful to my three supervisors:

Firstly, I want to express my gratitude to *Eva Nissen* my main-supervisor and the most indispensable person for this thesis. Thank you for introducing me to the field of scientific midwifery research, inspiring discussions and for sharing your great scientific knowledge and wisdom. You have always guided and supported me throughout the hard work and writing of this thesis. Thanks for having been my mentor, friend and for all laughs! You will stay forever in my heart and memory.

*Kerstin Uvnäs-Moberg*, my co-supervisor, I thank you for generously sharing your scientific knowledge about “the oxytocin puzzle” and for encouraging discussions. Thanks for your devotion and for teaching me to take a step “beyond”.

*Ann-Marie Widström*, my co-supervisor, for enriching me with your scientific knowledge in midwifery, for showing ways of seeing small details in newborns’ behaviour.

Thank you for your confidence in me and for all time that you have dedicated to me.

*Kyllike Christensson*, head of the *Division of reproductive health*, thanks for being so friendly, supportive and generous during my time as a PhD-student. Thank you for introducing me in the international field and sharing your great evidence based knowledge in teaching midwifery training in Nicaragua. *Anna-Berit Ransjö-Arvidsson*, my mentor and friend. Thank you for introducing me to the World Alliance of Breastfeeding Action Network, for inspiring discussions and for sharing your great knowledge in international midwifery research. *Ann-Sofie Matthiesen*, one of my co-authors, statistician and friend who guided me during the statistical analysis for your inspiring discussions, support and valuable suggestions. *Barbara Welles-Nyström*, one of my co-authors and my anthropologist, thanks for your inspiring discussions, support and valuable suggestions.

All former and present staff members at the *Division of reproductive health*, for a friendly environment and true support, especially *Anna Hjelmstedt*, *Anette Kaplan*,

*Cristina Westerberg, Iris Ronnevi, Sabine Blix, Annika Samsio, Kristina Gemsell, and Astrid Häggblad.* A special thanks to *Barbro Hedman* and *Charlotte Ovesen* for your friendship and excellent practical support along the way. I like to greatly thank *Bronwen Halloway* for urgent support in language editing, *Hans Järnbert-Pettersson* for statistical advice and *Gudrun Sandgren* for helpful transcription of videotapes.

I wish to thank all my colleagues at Danderyds hospital, for encouragement and letting me carry out research at the department. A special thanks to *Birgitta Mörlin*, head of the department, for supportive discussions.

My former and present fellow doctoral students *Sofia Zwedberg, Annette Ekström, Ksenia Bystrova, Cecilia Ekéus, Elisabeth Hertfeld, Karen Odberg, Ann Olsson, Malin Bergström, Eva Andersson, Malin Söderberg, Gunilla Lilja, Louise Seymyr, Björn Salomonsson, Linda Johansson Handlin and Pauline Binder.* A special warm thanks to my room-mates and lovely friends *Wibke Jonas, Ann Dsilna, Emma Fransson* and my dear co-author *Kristin Svensson.* I will also thank *Farzeen Tanwir and Yuki Takahashi,* post doctoral friends. Thank you all for inspiring discussions, support and wonderful time spent together over the years. *Lorena Binfa,* my Chilean sister and beloved friend, for being an inspiration in Chile and in Sweden. I am grateful for your kindness and generosity. A special thanks to *Hilda Bonilla,* director of the Midwifery School in Chile for your support during my stay in Santiago de Chile.

Finally, my deep gratitude goes to my family; my parents *Rakel and Lage* for endless support and love. My lovely “grown-up” children for *Fredrik and Emily* and their partners *Helena and Micke* for always being close and encouraging, you are important part of my life. My brother *Johan* who inspired me to get involved in the research field and *Marie,* my dear sister-in law, my lovely nephews, *Evelina* and *Marcus,* are important part of my life. *Cesar, Sara, Felix, Linnea, Milton, Tatiana, Bibi, Micke, Luna, Matteo, Fernanda, Pelle, Johan och Gunilla* thanks for chairing inspiring and special moments together.

Last but not least I thank my beloved husband and friend *Fernando Velandia,* thanks for supporting me, your guidance and patience over the years.

The thesis was supported by grants from Vardalsstiftelsen, the Swedish Research Council, (K 1999-27P-13085-01A, and K2001-27P-13085-036); the Swedish Order of Freemason; the Mjölkdroppen Foundation in Stockholm; the Swedish Foundation for Health Care Sciences Stockholm, the Solstickan Foundation, Strategic Research Program for Caring Science. Financial support was provided through the regional agreement on medical training and clinical research (ALF) between Stockholm County Council and Karolinska Institutet.

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