Fall 11-14-2018

Maternal sexuality during lactation: The influence of breastfeeding recency and relationship quality

Melissa A. Eaton
University of New Mexico

Melissa Anne Eaton
Candidate

Department of Psychology
Department

This dissertation is approved, and it is acceptable in quality and form for publication:

Approved by the Dissertation Committee:

Steven Gangestad, Chairperson

Marco Del Giudice

Melissa Emery Thompson

Geoffrey Miller

MATERNAL SEXUALITY DURING LACTATION:
THE INFLUENCE OF BREASTFEEDING RECENCY AND RELATIONSHIP QUALITY

by

MELISSA ANNE EATON

B.S. Psychology, Arizona State University, 2004
M.S. Psychology, University of New Mexico, 2010
Ph.D. Psychology, University of New Mexico, 2018

DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy
Psychology

The University of New Mexico
Albuquerque, New Mexico

December 2018

ACKNOWLEDGEMENTS

I would like to thank Dr. Steven Gangestad, my faculty advisor, for his support, guidance, and consideration throughout my long school career. I would also like to thank my dissertation committee, Dr. Marco Del Giudice, Dr. Melissa Emery Thompson, and Dr. Geoffrey Miller, for their time, guidance, and suggestions on this project. Finally, I would like to thank my family, especially Brett, Brom, and Liesel, for their unconditional love and support while I invested all of my energetic resources into this project.

MATERNAL SEXUALITY DURING LACTATION: THE INFLUENCE OF BREASTFEEDING RECENCY AND RELATIONSHIP QUALITY

BY

MELISSA ANNE EATON

B.S. Psychology, Arizona State University, 2004
M.S. Psychology, University of New Mexico, 2010
Ph.D. Psychology, University of New Mexico, 2018

ABSTRACT

Introduction. During lactation, breastfeeders report reduced sexual desire and sexual activity (Von Sydow, 1999). Yet research has not examined the direct impact of suckling on sexuality during lactation. This study looked at breastfeeders, immediately following breastfeeding and several hours later, to determine if the recency of infant suckling influences maternal sexuality. Sexual motivations were also compared between breastfeeders and other mothers. **Methods.** Mothers of infants between 2 and 7 months of age participated in the repeated measures study online. Participants were randomly assigned to the order of their sessions and participated 20 minutes after breastfeeding or 120 minutes after breastfeeding. **Results.** In breastfeeders, in-pair sexual desire was significantly lower 20 minutes after breastfeeding than 120 minutes after breastfeeding. Breastfeeders and all mothers in high quality current relationships also reported less extra-pair sexual desire and higher partner-connection sexual motivations than mothers in low quality current relationships. **Conclusions.** There is some support that the recency of breastfeeding and quality of the pair-bond may impact postpartum sexuality. This research suggests that recent breastfeeding reduces in-pair sexuality and that relationship quality may drive different sexual motivations. Future analyses should utilize greater experimental

control on breastfeeding timing, examine hormonal correlates, and include a larger sample size.

TABLE OF CONTENTS

List of Figures

List of Tables

Maternal sexuality during lactation: The influence of relationship quality and breastfeeding recency

Introduction

Life History Theory

Humans have limited energetic resources that must be allocated between different survival enhancing activities according to the human life history framework. Natural selection favors individuals that gather energy efficiently and distribute resources effectively in ways that maximize survival and fecundity. Because resources are limited, energy invested toward one activity cannot also go toward another activity. Thus, individuals face ongoing inherent trade-offs in allocating their energy.

Parental investment is one important expenditure in life history strategy. Human babies are energetically expensive and reach maturity later, requiring prolonged investment compared to other mammals (lactation, provisioning, extended food-sharing, child care, etc.) (Dufour & Sauther, 2002). Due to the length of investment, human mothers provide for multiple children at the same time and face forced trade-offs in reproductive investment between the quantity and quality of their offspring. During this time, mothers may also be investing in mating effort to retain their current partner. In other words, maternal energetic resources are shared between parental effort in the existing child(ren) (quality of offspring), reproductive effort into future children (quantity of offspring), and pair-bond maintenance. This is especially true during the lactational period when mothers are investing body energy to produce milk for a current child, but might also invest in the return to fertility, and a potential new pregnancy.

Mothers favor balancing these energetic expenditures such that their reproductive success is maximized. This means finding the best balance between current offspring and future offspring, without detracting from the health and survivability of either. The mother's energetic load, based on her energy intake and energy output, may influence how resources are allocated within this balance. Varying environmental and biological factors (like food availability and paternal investment) may influence the amount of maternal investment needed to maximize offspring success (survival, reproduction, etc.) and maternal success (survival, fertility). Thus, maternal reproductive strategies likely vary dependent on the maternal developmental environment, the current environment, and social factors, while the energetic investment into each child will depend on the maternal reproductive strategy, as well as the current environment (Bogin, Silva, & Rios, 2007; Ellison, 2005; Valeggia & Ellison, 2009; Worthman & Kuzara, 2005).

Healthier mothers with greater energy stores experience less energetic constraints and may be able to afford simultaneous investment in lactation and childcare, while investing in future reproduction. Indeed, Lanza, Valeggia, and Pelaez (2013) hypothesize that increased access to nutrition amongst Toba mothers is what accounts for the recent increase in maternal fertility rates. Conversely, less healthy mothers, and those with fewer energetic resources, may be constrained to fewer overall offspring (Wiley, 1998). Alternatively, in times of energetic stress mothers may also focus on quick and less costly reproduction, investing in large numbers of offspring, but expending less parental investment into them (early weaning and early supplemental foods)(Gibson & Mace, 2006; Valeggia & Ellison, 2009). One way energetic load may optimize offspring birth and timing is by inhibiting fertility when energy balance is lower than the norm.

Lactational Fertility

After parturition most women experience a short period of infertility known as postpartum amenorrhea. This amenorrhea lasts longer for women who breastfeed (Jones, 1989) than for women that do not breastfeed. The delay in ovulation is due to the costliness of milk production (Ellison, 2003) and is known as lactational amenorrhea. Due to lactational amenorrhea, breastfeeding is a common method of birth control in many countries (Short, 1993) and has been shown to be effective in reducing fertility (Gross & Burger, 2002). Therefore, breastfeeding has additional benefits to the child, by reducing maternal fertility and thus, providing extended access to maternal milk and attention.

Lactational amenorrhea varies in length between women and between cultural groups. Literature indicates vast disparities on the fertility of lactating mothers. The differences in the duration of lactational amenorrhea may be due to differences in maternal energy balance. Some mothers have access to more resources than other mothers and other mothers have higher energetic costs than others. The "metabolic load hypothesis," proposes that it is the combination of energy intake and energy output during lactation that is important in determining the length of lactational amenorrhea and whether the mother could support another life (Ellison, 2001; Ellison, 2003; Valeggia & Ellison, 2004; Valeggia & Ellison, 2009).

Better nourished women return to fertility before those that are undernourished (Kirchengast & Winkler, 1996; Wasalathanthri & Tennekoon, 2001). Other findings correspond. Underweight (BMI under 18.5) breastfeeding mothers were more likely to stay amenorrhoeic than other breastfeeding mothers and breastfeeding mothers with higher more energetically-demanding jobs had longer lactational amenorrhea (Rosetta & Madcie-Taylor, 2009). Similarly, Toba mothers' high nutritional and more sedentary activities account for the short periods of lactational amenorrhea and retained body fat over the lactational period, despite exclusively breastfeeding (Valeggia & Ellison, 2003). Low nutritional status also has a stronger negative impact on lactational amenorrhea the longer a mother breastfeeds (Peng, Hight-Laukaran, Peterson, & Perez-Escamilla, 1998). The longer a mother has a negative energy balance, the longer it will be until she can conceive again. This contributes to the length of time between the birth of her offspring.

Interbirth Interval

The duration of interbirth intervals (spacing between births) is important for both mother and offspring fitness. Mothers must balance the length of time between births to maximize benefits and minimize the costs of her reproductive strategy. Thus, optimal birth spacing will vary depending on maternal reproductive strategy and environment (Blurton-Jones, 1986; Thomas et al., 2015). Lengthier interbirth intervals result in an opportunity cost to the mother, as they imply a loss of time during which she could have been investing in an additional offspring. Yet with shorter interbirth intervals, the mother may find herself directly investing energetic resources, not just into two, but into three individuals, as the current child is likely to be breastfeeding during a pregnancy.

Short interbirth ratios are costly for mothers. If the mother is breastfeeding during pregnancy, there are high energetic costs for her, evidenced by lower weight gain (Ayrim, Gunduz, Akcal, & Kafali, 2014), and decreases in fat stores during pregnancy (when most mothers are gaining weight), despite increases in supplementation and little differences in infant growth (Merchant, Martorell, & Haas, 1990a and b). Likewise, mothers with shorter interbirth ratios have lower bone mineral density (Stieglitz et al., 2015). Short interbirth ratios also risk lost maternal investment into offspring that has a lower chance of survival, as short interbirth intervals are associated with preterm labor (Huber, 2008) and mortality risks for unborn infants (Da Vanzo, Hale, Razzaque, & Rahman, 2008).

Comparably, short interbirth intervals are also adverse for children. The longer the interbirth interval, the better health and survivability of the child (Abebe & Yohannis, 1996; Da Vanzo et al., 2008). Short interbirth intervals put infants at risk for low birth weight ("Undernutrition among," 1996), undernutrition (Rutstein, 2005), and stunted growth (Forste, 1998). The risks of short interbirth intervals are likely responsive to maternal energy balance. Risks are higher for offspring when maternal resources are low (De Jonge et al., 2014) and may depend on maternal energetic output into the previous offspring. Newborns gain less weight in their first postpartum month if their mother breastfed a sibling during late pregnancy (Marquis, Penny, Diaz, & Marin, 2002). In a study comparing the mortality risks for live births, still births, miscarriage, and early abortion, Da Vanzo et al. (2008) discovered that the result of the previous pregnancy differentially impacted the mortality risk for the sibling. Mortality risks were higher for infants born after a sibling's live birth, than for those born after a non-live birth (stillbirth, miscarriage, etc.). Similarly, the mortality risk is also strongest for infants whose elder sibling is still alive when they are born. This is expected, as live siblings are more energetically expensive than lost pregnancies or still births, as it results in sharing maternal and paternal resources amongst more offspring.

Mother offspring conflict and interbirth interval. While closely spaced interbirth intervals are detrimental to all, infants benefit from longer interbirth intervals, than would maximize their mothers' fitness. The increases in offspring that might maximize maternal fitness will not reciprocally maximize offspring fitness, as a child is 100% related to itself, but only 50% related to its siblings. Indeed, Haig argues that maternal genes may promote shorter interbirth intervals than do microchimeral fetal genes or offspring genes of paternal origin (2014a). For a child, it may be best to limit parental investment to be dispensed between themselves and their older siblings for a longer time than would benefit mothers. Longer interbirth ratios mean extended periods of investment in the current child(ren), including breastfeeding, and constrain the mother's absolute number of offspring due to maternal age-related constraints on child bearing. This benefits the existing offspring, as there are less siblings with whom to share parental time and resources. Sibling competition for parental resources may play a role in the relationship between maternal fecundity and offspring survival (Lawson, Alvergne, & Gibson, 2012). In rural Africa, children of mothers of more than 5 children have greater mortality risks (Van den Broeck, Eeckels, & Massa, 1996). High maternal parity is also associated with low birth weight ("Undernutrition among," 1996) and low milk supply (Martin, Garcia, Kaplan, & Gurven, 2016). Thus, the wider the interbirth interval, the longer an offspring has to be the singular recipient of parenting effort or the less siblings the offspring must share parenting effort between.

Interestingly, despite research on the birth interval prior to an offspring's birth (time period between older sibling's birth and current child), it has a lesser impact on health and mortality than the birth interval following that offspring's birth (time period between current child and younger sibling's birth) (Da Vanzo et al., 2008: Kuate, 1997). Children born before another sibling are two times as likely to die than children that are the last sibling to be born into Nairobi families with minimal resources. (Fotso, Cleland, Mberu, Mutua, & Elungata, 2013). One important factor in the relationship between child health and interbirth ratio may be the length of access to breastfeeding. Last-born offspring have lower mortality and are breastfed longer than their older siblings (Jayachandran& Kuziemko, 2011). Short prior interbirth intervals would not impact an infant's access to breastmilk, however short subsequent interbirth intervals would limit access.

During pregnancy milk production decreases and sometimes ceases (Moscone & Moore, 1993). As milk production is thought to provide the nutrients that a child needs for their stage of development (Bardanzellu, Fanos, Strigini, Artini, & Peroni, 2018), the mother's body may then begin to respond to the needs of the new infant, in addition to the current child. During pregnancy, milk composition changes and there may be changes in the taste of milk (Prosser, Saint, & Hartmann, 1984) which could be aversive to breastfeeding children leading infants to self-wean. Milk composition stays altered even after parturition for mothers that breastfeed throughout pregnancy compared to mothers that did not (Marquis, Penny, Zimmer, Diaz, & Marin, 2003).

The necessity of providing direct energetic resources to children with differing needs may result in shortfalls to the elder child. Children are more likely to be weaned if their mother is pregnant (Bohler and Bergstrom, 1995) and early weaning may result in costs and risk for that infant (e.g., stunted growth; Forste, 1998) and higher mortality (Fotso et al., 2013). Additionally, children weaned during their mother's pregnancy grow less during their last few months of breastfeeding than children weaned at the same age by non-pregnant mothers (Bohler & Berstrom, 1996), suggesting that the quality of maternal milk may not be as high during pregnancy. Thus, the longer an infant can postpone their mothers' return to fertility and extend the interbirth interval, the longer that child can breastfeed, and the more energy the mother can put into milk production.

Lactational amenorrhea, Interbirth Intervals, and Breastfeeding

Maternal reproductive strategies are complicated by the dynamic of human relationships. In some cases, maximizing an offspring's fitness is congruous with maximizing maternal fitness, yet other times conflicts arise between maximizing maternal fitness and maximizing offspring fitness. These conflicts between mothers and their offspring center around the length of and amount of maternal investment (Trivers, 1974) and may peak around the time that mothers start to return to fertility (Haig, 2014b). During lactation, infants benefit from longer periods of maternal infertility, wide birth spacing, and more extended breastfeeding than would benefit mothers. On the other hand, mothers often benefit from shorter periods of infertility, more narrow birth spacing, and earlier weaning.

Maternal lactational infertility, birth spacing, and breastfeeding are interrelated, and may all be sensitive to maternal energetic loads. Breastfeeding leads to metabolic costs that are associated with the length of lactational amenorrhea and the duration of lactational amenorrhea impacts interbirth interval by postponing ovulation.
However, one study found that breastfeeding for two years was related to longer subsequent interbirth intervals (Mattison, Wander, & Hinde, 2015). Thus, breastfeeding

may provide infants an opportunity to extend the birth interval further, beyond the limits of lactational amenorrhea.

Breastfeeding

Lactation is a large energy expenditure for the mother. Her body must provide nutrients and convert them into milk (Prentice & Prentice, 1988). While pregnancy is expensive for mothers, the energetic costs of lactation are even higher (Butte & King, 2005; Jasienska, 2009), with some women offsetting costs by eating more and reducing physical activity (Dufour & Sauther, 2002). Infants are larger during lactation than they were as a fetus and are growing and developing rapidly. While efficient, milk composition is also reactive to circumstances and to these differing needs as the infant develops (Bardanzellu et al., 2018). For example, milk contents at night may help infants sleep (McGuire, 2013); milk contents during infant illness have more immunological components (Riskin et al., 2012); and the social networks available to mother and baby may impact the human milk microbiome (Meehan et al., 2018).

Lactation also often lasts longer than the gestation period. Infants are recommended to exclusively breastfeed for the first 6 months of their lives (mother is sole source of food) (American Academy of Pediatrics, 2012; World Health Organization, 2011). When it becomes difficult for the mother to meet the infant's energetic demands, supplementation starts. The American Academy of Pediatrics recommends that infants drink breast milk along with eating solid foods until their first year (2012), while the World Health Organization recommends breastfeeding until age 2 (2011). Still, in traditional societies breastfeeding may go much longer (Quinlan & Quinlan, 2008; Sellen, 2001).

Breastfeeding and mother offspring conflict. Breastfeeding confers direct benefits to infants, plus helps solidify future benefits by promoting bonding and potentially delaying or reducing future sibling competition. Breastmilk contains far more than the necessary nutrients for a child to grow. Breastmilk colonizes the infant's gut (Goldsmith, O'Sullivan, Smilowitz, & Freeman, 2015), impacts metabolism (Bardanzellu et al., 2018), aids in immunological development (McDade et al., 2014), and may sway the infant behavioral phenotype (Hinde et al., 2015). Breastfeeding also plays an important role in maternal responsiveness and the long-term mother-child bond (Kim et al., 2011; Weaver, Schofield, & Papp, 2018).

While prolonged lactation is beneficial to the child for multi-faceted reasons, it imposes direct energetic costs to the mother in addition to opportunity costs from lengthened period of lactational amenorrhea and longer interbirth interval. While mothers with extreme nutrition deficiency are able to lactate (Lunn, Austin, Prentice, & Whitehead, 1984; Prentice & Prentice, 1995), it is costlier for them. In a 2015 study, BMI decreased more for breastfeeding mothers than formula feeding mothers (Hruschka & Hagaman). Their findings also showed BMI decreases were less drastic for wealthy mothers, as they had gained more weight during the pregnancy period. Similarly, in another study, mothers with more nutritional resources gained weight sooner during lactation and had a faster return to fertility (Valeggia & Ellison, 2009). Thus, the lactational costs depend on maternal condition and resources.

Physiologically, mothers may manage the energetic costs of lactation by swiftly returning to fertility once their energetic load allows it. Mothers usually return to fertility sometime during the lactational period, once their energetic balance is high enough to maintain lactation while investing in future reproduction, or once the child weans. Chimpanzee research indicates that after a short period of time of weight gain, breastfeeding mothers are able to start ovulation (Emery Thompson, Muller, & Wrangham, 2012). Human research has also found a correlation between weight gain over the course of months prior to starting menstruation (Valeggia & Ellison, 2009). Thus, maternal fertility is not just sensitive to the current conditions, but also how they relate to previous conditions (Vitzthum, 2009). Mothers may also return to fertility earlier based on other changes to their energetic status, such as the death of a breastfeeding infant (Aryal, 2010).

Maternal costs are also managed through the design of the lactational system. Gene activations and suppressions needed for lactation are fixed during pregnancy (Lemay, Neville, Rudolph, Pollard, & German, 2007), making it difficult for infants to behaviorally manipulate gene expression. Then, early on in lactation, production responds to infant demand, minimizing maternal costs due to overproduction (Daly & Hartmann, 1995a and b). Over time the mammary glands gradually decrease milk production due to lack of RNA upkeep of lactation processes (Lemay et al., 2007). Likewise, some aspect of breastfeeding appears to limit milk demand from infants, as breast-fed infants show better self-regulation of milk intake than do bottle-fed and combination-fed infants (Li, Fein, & Grummer-Strawn, 2010). It has also been suggested that maternal milk may influence infant behaviors, like crying, that may be related to resource acquisition, through differences in gut microbiota (Allen-Blevins, Sela, & Hinde, 2015).

Behaviorally, mothers may manage the costs of lactation by supplementing with food or weaning their infant. Early supplementation and weaning are thought to help mothers return to fertility or invest in concurrent pregnancy (Berhanu & Hogan 1998; Dada et al., 2002). Tay, Glasier, and McNeilly (1996) found that the introduction of solid foods into breastfed babies' diets correlated with the length of lactational amenorrhea. In modern environments, formula may also help mothers, as the differences in the length of lactational amenorrhea between undernourished and well-nourished mothers are partially controlled for by supplementation with formula (Wasalathanthri & Tennekoon, 2001).

In an infant-centered world, an infant would have all of the milk it wants, whenever it wants, containing the nutrients it needs the most. However, unlimited access to maternal resources is not possible within the confines of maternal milk production and given the autonomy mothers have in limiting access to breastmilk. Mothers may decide to supplement foods, limit feeding times, and may wean infants whenever they choose. There may also be maternal physiological mechanisms limiting the amount of milk production or ingredients, especially as the infant ages.

Lactational sexuality

In addition to the physical constraints during lactation due to inhibited ovarian function and metabolic load, maternal sexual interest and behavior may also contribute to the length of interbirth intervals. Mothers (and fathers)-to-be experience changes in their sexual relationship starting during pregnancy (Schroder & Schmiedeberg, 2015). Parents of infants up to 12 months are affected by many post-partum sexual concerns related to sexual desire, frequency, fatigue, and breastfeeding (Schlagintweit, Bailey, & Rosen, 2016; Woolhouse, McDonald, & Brown, 2012). Sexual activity itself is reduced during pregnancy (Barclay, McDonald, & O'Loughlin, 1994; Georgakopoulous, Dodos, & Mechleris, 1984; Lumley, 1978; Von Sydow, Ullmeyer & Happ, 2001) and fails to change much after delivery (Condon, Boyce & Corkindale, 2004). These decreases in sexual desire and frequency remain through the first few months of a child's life (Von Sydow, 1999) and may be diminished for 12 months postpartum (Condon et al., 2004; Reamy & White 1987). Other studies suggest that maternal sexuality may be suppressed for much longer, with lower levels for the first few years of a child's life (Schroder & Schmiedeberg, 2015) and reduced sexual activity while children aged 4 and under are at home (Call, Sprecher, & Schwartz, 1995). The sudden drop followed by continued suppression of sexual behavior and desire after birth, instead of a recovery to pre-pregnancy levels, is indicative that there is something about early parenthood impacts sexual activity.

Postpartum sexual dysfunction is more common in breastfeeding women than non-breastfeeding women (Alder, 1989; Alder & Bancroft, 1988; Avery, Duckett, & Frantzich, 2000; LaMarre, Paterson, & Gorzalka, 2003; Rezaei, Azadi, Savehmiri, & Valizadeh, 2017). Malakoti, Zamandzadeh, Meleki, and Farshbaf-Khalili (2012) found sexual dysfunction in almost all 200 of their breastfeeding participants. In another recent study, breastfeeding was found to be one of the largest risk factors for postpartum sexual dysfunction (Wallwiener et al., 2017). These sexuality differences do not appear to be pre-existing, as those that end up breastfeeding and those that end up bottle-feeding report similar sexual behavior before pregnancy (Alder, 1989; Alder & Bancroft, 1988). Breastfeeding may be influencing fertility directly through lactational amenorrhea and indirectly by reducing sexual desire, function, and activity. Mothers do not appear to immediately recognize the impact that breastfeeding has on their sexuality. After weaning, 45.3% of mothers indicated that breastfeeding had negatively impacted their sexuality, however, early-on at 1 month postpartum, 74.6% indicated it was not a problem (at that time, many had probably not resumed sexual activity) (Avery et al., 2000).

Breastfeeding women resume postpartum intercourse later than their formula-feeding counterparts (Alder & Bancroft, 1989; Byrd, Hyde, DeLamater, & Plant, 1998; Rowland, Foxcroft, Hopman, & Patel, 2005; and Von Sydow, 1999). The delay in postpartum sex is not seen in mothers that stop breastfeeding early-on and seems to hold true even for mothers that are supplementing breastfeeds with formula (Rowland et al., 2005). Yet, the timing may differ only by about a week between breastfeeders and non-breastfeeders in westernized culture (Alder & Bancroft, 1989; Byrd et al., 1998). Thus, while it is a statistically significant difference, it may not have a large overall effect on extending interbirth intervals. On average, new mothers in these westernized cultures reported returning to sexual activity around 7 weeks (Byrd et al, 1998) or 2 months (Von Sydow, 1999) postpartum, several months earlier than in other cultures (Adinma, 1996). Yet, in all cases the resumption of intercourse is still likely starting before lactational amenorrhea has ended.

More significantly, breastfeeding mothers report having less frequent sexual activity than non-breastfeeders (Ahlborg, Dahlof, & Hallberg, 2005; Barret et al., 2000; De Judicibus & McCabe, 2002; Visness, & Kennedy, 1997; Von Sydow, 1999). Sexual activity is consistently lower in breastfeeders at different points post-partum.

Breastfeeders report having less sex at 1 month postpartum (Byrd et al., 1998), 4 months postpartum (Byrd et al., 1998), 6 months postpartum (Ahlborg et al., 2005); and may remain reduced for the 12 months postpartum (Von Sydow, 1999).

The loss of sexual desire is one of the most common sexual concerns of breastfeeding mothers in the postpartum period (Malakoti et al., 2013) and may be one of the largest differences in sexual functioning between breast and bottle-feeders (LaMarre et al., 2003). The length of breastfeeding is associated with the decreases in sexual desire (Avery et al., 2000). Thus, mothers that breastfeed longer may show greater declines or longer suppression of sexual desire. Studies have found lower levels of sexual desire in breastfeeding women at 3 months postpartum (Alder & Bancroft, 1988) and 6 months postpartum (Ahlborg et al., 2005). A study of mothers at 6 months postpartum, found that mothers reporting the most severe loss in sexual interest were all breastfeeders (Alder & Bancroft, 1983). These lower levels of sexual interest may impact the timing of resumed intercourse in breastfeeders and the lower frequency of sex.

Breastfeeding mothers also display declines in sexual satisfaction from pre-pregnancy levels (Barret et al., 2000; Yee, Kaimal, Nakagawa, Houston, & Kupperman, 2013) and exclusively breastfeeding mothers show lower sexual satisfaction than other new mothers (Yee et al., 2013). Breastfeeding mothers have lower sexual satisfaction at both 1 month postpartum, 4 months postpartum (Byrd et al., 1998) and 6 months postpartum (Ahlborg et al., 2005), but not at 12 months postpartum (Byrd et al., 1998). The degree of sexual satisfaction may be associated with the lower intensity of orgasm found for some breastfeeders (Von Sydow, 1999). Breastfeeding may also be related to other sexual dysfunctions that impact desire, satisfaction, and frequency. Sexual arousal is lower in breastfeeding mothers (Malakoti et al., 2013), as is enjoyment (Von Sydow, 1999). Dyspareunia (pain during sex) is much more common in breastfeeding mothers (Signorello et al., 2001; Von Sydow, 1999) and may remain a problem for longer than bottle-feeders. At 6 months postpartum, 36% of breastfeeding mothers still noted experiencing pain during sex (Von Sydow, 1999).

Sexual conflict in the pair-bond. Fathers also report a decrease in sexual functioning during pregnancy (Gray & Anderson, 2010). While sexual functioning improves during the first year from the pregnancy levels, it does not recover to pre-pregnancy levels. The lack of recovery in sexual functioning is a surprise for fathers, as about 52% reported lower sexual activity than they expected (Condon et al., 2004), despite expectations that the baby will be the primary focus after birth and that there will be a delay in sexual activity (Olsson, Robertson, Bjorklund, & Nissen, 2010). Yet, even with lower expectations and their own decrease in desire (smaller and for a shorter time than the mother)(Gray and Anderson, 2010), there is still a disparity. The new mismatch between new fathers' and new mothers' sexual desire and the reduction in sexual activity are primary sexual concerns for both parents (Schlagintweit et al., 2016; Woolhouse et al., 2012). Even 12 months after birth, new parents report being only somewhat satisfied with their sexual life (Leavitt, McDaniel, Mass, & Feinberg, 2017). Mothers are concerned about their lessened sexual desire, and experience guilt about its lowered levels (Woolhouse et al., 2012). New fathers become more disappointed with the lack of sexual engagement with their partners as time passes (Condon et al., 2004).

Partnership maintenance is an important investment during the lactational period. When relationship quality is low, the father may not invest as much in the offspring

(Carlson, Pilkauskas, McLanahan, & Brooks-Gunn, 2011; Cox, Owen, Lewis, & Henderson, 1989), increasing costs to the mother in providing for her offspring. Parents report lower relationship satisfaction (Twenge, Campbell, & Foster, 2003) and greater declines in relationship satisfaction (Lawrence, Rothman, Cobb, Rothman, & Bradbury, 2008) than non-parents. This may be partly due to the reduced sexual functioning and sexual satisfaction exhibited in parents. Sexual satisfaction and relationship satisfaction are interrelated (McNulty, Wenner, & Fisher, 2016) and worries about their sexual relationship in the postpartum period impact the partners' relationship satisfaction (Schlagintweit et al., 2016). Thus, mothers in quality pair bonds have a considerable interest in supplying access to sex during pregnancy and the postpartum period, even when her own fertility and interest in sex are low.

Sexual activity in postpartum breastfeeding women resumes earlier than their desire returns (Von Sydow, 1999) and before lactational amenorrhea ends (Labbok et al., 1997; Moran, Alcazar, Carranza-Lira, Merina, & Bailon, 1994). Yet despite reduced low fertility and desire, new mothers are receptive to sex from their partner. This suggests that women are engaging in sex for reasons other than conception and their own sexual desire and may be receptive to sex for the purposes of relationship maintenance. Research indicates that mothers do consider their partner's wishes in the resumption of sexual intercourse (Adinma, 1995). Twenty-eight percent of new mothers report that postpartum sex was initiated by the father, while only 5% of new mothers reported initiating the postpartum resumption of sex themselves (Barrett et al., 1999). Despite the lower sexual interest, the majority of new mothers also report enjoying sex during the postpartum (Von Sydow, 1999). Mothers may also engage in sexual activity other than intercourse to make up for the decrease in intercourse. Mothers report performing oral sex before engaging in sex or receiving oral sex (Hipp, Kane Low, & van Anders, 2012). New fathers also describe extending their interpretation of sexuality to include being physically close and touching (Olsson et al., 2010). Receptivity to partner's sexual advances and engaging in alternative sexual activities may be part of a strategy to maximize paternal investment, as maternal investment in the partnership encourages the father to remain and provide additional resources.

Factors impacting lactational sexuality. Evidence indicates that breastfeeding impacts maternal sexuality. However, some studies have failed to find inhibitory effects of breastfeeding, especially in developed countries (De Judicubus & McCabe, 2002; Hipp et al., 2012; Schlagintweit et al., 2016). Other studies find opposing effects, such as an earlier resumption of intercourse for breastfeeding mothers (Signorello et al., 2001) and a small subsample of women that report increased sexuality during lactation (Escasa-Dorne, 2015). Just as lactational amenorrhea varies depending on the environmental factors and maternal energy balance, so might sexuality. Breastfeeding alone does not explain all changes in sexual activity, motivation, and desire. Variation in the sampling population and the variables that are measured or controlled may drive the discrepancies. The relationship between breastfeeding and sexuality is complex, and sensitive to a variety of energetic and social characteristics, some of them interrelated.

Characteristics of breastfeeders. One issue is the potential for confounding factors with breastfeeders. Breastfeeding may be more common in older mothers and mothers with more children (Ukegbu, Edenebe, Ukegbu, & Onyeonoro, 2011). Sampling breastfeeders may also mean sampling a more fecund group (Vitzthum, Spielvogel, Caceres, & Gaines, 2000). It is also possible that women that are more comfortable with their bodies (Brown, Rance, & Warren, 2015; Hauff & Demerath, 2012) and their sexuality may be more likely to breastfeed. However, maternal age, number of offspring, and body image are not related to the postpartum sexuality differences displayed by breastfeeders (Hipp et al., 2012; Visness & Kennedy, 1997). Likewise, the sexuality differences do not appear to be pre-existing, as those that end up breastfeeding and those that end up bottle-feeding report similar sexual behavior before pregnancy (Alder, 1989; Alder & Bancroft, 1988).

Relationship quality. Mothers in committed partnerships may be balancing energy allocation between investment in offspring and investment in their partnership. Kenny (1973) found that breastfeeding mothers, those with longer marriages, and those with more children had an earlier return of sexual interest. This is expected, as those with greater energetic need and those with committed partners have the most to gain by continued investment into their current relationship. Paternal investment is an asset in caring for human infants (Geary, 2000) and provisioning rates are higher from males in relationships with breastfeeding females (Marlowe, 2003). Thus, these mothers have a greater interest than others in maintaining the current relationship.

By contrast, those in poor quality relationships may concentrate energetic resources into parenting effort. Indeed, Fisher (1989) found that divorces peaked about 4 years after the birth of a child, suggesting that mothers in poor relationships wait until the need for parental investment expenditures lessened before searching for a new mate. During the years immediately following childbirth, mothers in poor quality relationships may experience less sexual desire and a lower frequency of sex, suggesting less energy allocation into mate retention. Poor relationship quality pre-pregnancy has been shown to be associated with sexual dysfunction (both postpartum and during pregnancy) (De Judicibus & McCabe, 2002; Wallwiener et al., 2017).

Stress negatively impacts sexual desire in non-lactating women (Raisanen, Chadwick, Michalak, & van Anders, 2018). In new mothers, their level of parental stress is predictive of their current sexual satisfaction of their partner (Leavitt et al., 2017). Parental stress may be indicative of partner support. Thus, mothers receiving support, may have added interest in maintaining their relationship. While mothers obtaining less support, may have lower interest in satisfying their partner's sexual needs.

While sexual frequency and function tend to be lower in breast-feeders, relationship satisfaction tends to be higher compared to non-breastfeeders (Schlagintweit et al., 2016). This difference may pre-exist the pregnancy, as women that go on to breastfeed may have more supportive partners (Hunter & Cattelona, 2014). As would be expected in supportive relationships, breastfeeding mothers also show higher relationship commitment than non-mothers (Escasa-Dorne, 2015) and may engage in sex motivated by maintaining their beneficial relationship. Studies of breastfeeding mothers should take into consideration the motivations for engaging in sex. Despite their lower desire, breastfeeders in high quality relationships may be motivated to engage in more sexual behavior to maintain their relationship than other mothers. Thus, resumption of intercourse and frequency of sexual activity may partly reflect relationship quality and not only the level sexual desire.

Energetic load. Maternal energy balances are a significant factor in how breastfeeding impacts sexuality. Women that breastfeed and stick with it, may have higher energy balances to begin with (greater resources; more partner provisioning; better health) and are capable of carrying lactation costs even as they expend energy into mating effort. Supplementing and early weaning may be more common in mothers with low energy balances and over all, weaning has a positive effect on sexual behavior (Von Sydow, 1999). With the end of weaning, the energy demands of the infant decrease, as do the lactational hormones. Mothers surveyed before and after weaning felt less fatigue, engaged in more sexual activity, and had more sexual interest after weaning (Forster, Abraham, Taylor & Llewellyn-Jones, 1994). Similarly, mothers have been known to increase sexual activity when other changes result in lower metabolic loads, such as after a child dies (Kimani, 2001).

Likewise, studies of breastfeeding and sexuality may be compromised by grouping women with different lactational expenditures together. Studies include a variety of definitions of "breastfeeding," such as those that exclusively breastfeed; or those that breastfeed at all (including that supplement with formula or solid foods; and those that have ever breastfed (including those that have weaned). Given the energetic impact of breastfeeding is an important component of its impact on sexuality, these definitional differences may partly explain differences in study outcomes.

Hormones. Research indicates that hormones present in pregnancy and early motherhood may play a role in both the physiological and psychological changes that females undergo to adapt to motherhood . These hormones are believed to be sensitive to changes in metabolic load (Ellison, 2017) and may modify physiological responses and sexual behavior to be in unison with maximizing maternal fitness and focusing attention in parental effort. Predictably, hormones related to sexual desire and behavior differ during the lactational period (testosterone- Alder, Cook, Davidson, West, & Bancroft, 1986; prolactin- Kruger, Hartmann, & Schedlowski, 2005; Unuane, Tournaye, Velkeniers, & Poppe, 2011; estrogen & progesterone – Grebe, Emery Thompson, & Gangestand, 2016; oxytocin- Veening, de Jong, Waldinger, Korte, & Olivier, 2015) and may be suppressing both ovulation and sexuality. For example, testosterone, a modulator of mating effort in males (Ellison, 2003), is lower in breastfeeders that report a loss of sexual desire (Alder et al., 1986). Similarly, prolactin, which helps suppresses ovarian function, is higher in breastfeeders (Hodson, Townsend, & Tortonese, 2010; Uvnas-Moberg, Widstrom, Werner, Mathiesen, & Winberg, 1990).

As pregnancy and lactational hormones return to near-nulliparous levels (Barrett, Parlett, Windham, & Swan, 2014), women experience improvement in sexuality. Breastfeeders that have resumed menstruation are less likely to face sexual dysfunction (Escasa-Dorne, 2015; Khajehei, Doherly, Tilley, & Sauer, 2015). They also exhibit higher sexual functioning than both breast-feeders that are not cycling and women without children (Escasa-Dorne, 2015). Few studies of sexuality during breastfeeding track resumption of menses or return of ovulation, though hormones involved in the cycle may be important indicators of the switchover to concurrent investment in current and future offspring.

Increasingly relevant in research is also the issue of hormonal contraceptives that may alter sexual responses and behavior. In the United States most women, including breastfeeders, are recommended to begin using contraceptives at their postpartum check-up (American College of Obstetricians and Gynecologists, 2018). Like the ovulatory cycle, few studies include or limit participant contraceptive use. However, one study of breastfeeding during maternal sexuality measuring contraceptive use at 6 months postpartum found that 37% of the sample used a hormonal form of contraceptive (Barret et al., 2000). Hormonal contraceptives are known to impact sexuality in some non-lactating women (Arslan, Schilling, Gerlach, & Penke, 2018; Burrows, Basha, & Goldstein, 2012) and are liable to also impact the sexuality of lactating women.

While hormones guide long-term energy allocation, they are also responsive to current indicators of opportunity or need, and may facilitate behavioral modifications, particularly in social situations (Ellison, 2003). For example, testosterone fluctuates in response to competition (Casto & Edwards, 2016) and increases during interactions with females (Roney, Mahler, & Maestripieri, 2003). Prolactin and oxytocin are both released in response to breastfeeding (McNeilly, Robinson, Houston & Howie, 1983); oxytocin is involved in infant interaction (Strathearn, Iyengar, Fonagy, & Kim, 2012); and prolactin is released in response to infant cries (Fleming, Corter, Stallings, & Steiner, 2002). Hence, hormone fluctuations during breastfeeding may be moderating sexual desire, motivations, and behaviors.

Infant Manipulation

As discussed, an advantage is had by infants able to guide the mother-offspring relationship in the direction of obtaining more resources from their mother than is optimal for maternal fitness. Evidence for this competition begins even before lactation, during pregnancy. For example, gestational diabetes increases resource acquisition for infants, but may be harmful to the mother (and if too successful, put the fetus at risk) (Haig, 1993). This competition continues on into the postpartum period through complex negotiations regarding breastfeeding, bonding, interbirth rations, and fertility. Indeed, fetal cells have been found in high concentrations in areas of the body related to lactation and bonding, like the maternal breasts, brain, and thyroid, and may be prompting maternal systems to act in their interest. (Boddy, Fortunato, Wilson Sayres, & Aktipis, 2015). In counterbalance, maternal miRNA cells have been shown to survive the digestive track and may alter immune and metabolic function in infants (Alsaweed, Hartmann, Geddes, & Kakulas, 2015; Alsaweed, Lai, Hartmann, Geddes, & Kakulas, 2016).

Infants may also dampen sexual desire (and affect ovulation) through their behavior, either by temporarily influencing maternal hormone responses or the metabolic energy balance. These conflicts are managed unconsciously, in pursuit of maximized health, survivability, and future fertility. Thus, these infant behaviors are not purposefully manipulative in order to hurt parents, but instead are expressed to optimize their own success. For example, reducing and interrupting maternal sleep may impact maternal metabolic function and energy expenditures (Bass & Takashi, 2010; Nedeltcheva & Scheer, 2014) and coincides with alterations in cortisol (Spiegel, LeProult, & Van Cauter, 1999) and prolactin (Diaz et al., 1989; Glasier, McNeilly, & Howie, 1984). As a consequence, night waking may reduce energy available for maternal sexuality (Blurton Jones & Da Costa, 1987) and extend lactational amenorrhea (Diaz et al., 1989; Glasier et al., 1984). Sex is resumed later in mothers whose infants wake more at night (Romito, 1988) and sex is less frequent (Alder & Bancroft, 1983). Night waking may also be a way to ensure more consistent (and possibly greater) investment from parents (Hinde, 2014). Haig (2014b) provides evidence that night waking is greater in breastfed infants than non-breastfed infants and greater for breastfed infants that are fed at night, than those that are not fed at night. Thus, night waking appears to be a greater benefit for breastfed infants for whom preventing maternal fertility is more advantageous.

Suckling Behaviors. Infants may possibly alter their breastfeeding behavior to impact maternal systems. Infant breastfeeding behaviors indicate nutritional demand (Wells, 2003) and may drive up the energetic costs for the mother, potentially reducing fertility. The act of suckling implies a need and thus more intensive suckling behaviors may signify a high energetic demand by the infant. This likely upregulates milk supply to meet infant needs (Daly & Hartmann, 1995). Thus, increases and variations in suckling may impact maternal energy allocation and balance. Higher intensity breastfeeding is more likely to result in lactational amenorrhea than less intensive breastfeeding (Zohoori & Popkin, 1996). There is also evidence that pausing during breastfeeding (Prieto, Cardenas, & Croxatto, 1999), feeding on demand, and using two breasts during feeding might result in longer amenorrhea (Zohoori & Popkin, 1996). However, longer nursing sessions (Stallings, Worthman, Panter-Brick, & Coates, 1996) and suckling pressure do not appear to be related to amenorrhea (Preito et al., 1999).

Some lactation related changes occur only in response suckling. Literature on lactation and stress indicates that lactation itself is not enough to blunt the cortisol stress response. Instead, stress is only suppressed in lactating women when measured immediately following a breastfeeding session. (Heinrichs, Meinlschmidt, Nueumann, Wagner, Kirschbaum, Ehlert, & Hellhammer, 2001; Heinrichs, Neumann, & Ehlert, 2002). Just as stress responses and cortisol release during lactation may depend on the timing of the last nursing session, so might sexual desire and motivation. While sexual desire is low overall during the lactational period, due in part to hormones, it may also follow the pulsatile secretions of lactational hormones, like prolactin and oxytocin (McNeilly et al., 1983). The hormones involved in lactation may be sensitive to opportunity and react to breaks from parental effort by upregulating maternal sexual interest and managing conflicts between the pair-bond and parenting effort.

Study Hypotheses

Sexual desire varies across the ovulatory cycle and is highest during the most fertile period (Arslan et al., 2018; Hill 1988; Pillsworth, Haselton, & Buss, 2004; Regan 1996). These changes may be due to the levels of progesterone and estrogen as they are both associated with in-pair and extra-pair desire (Grebe et al., 2016). Sexual desire is also lower during pregnancy and early lactation (Von Sydow, 1999) when conception is not probable. Yet, women engage in sexual activity across the ovulatory cycle, during pregnancy, and during lactation. Female sexual desire and behavior may then be differentially sensitive to metabolic, endocrine, and social indicators that suggest advantageous timing for sexual activity or pregnancy. This allows sexual desire and activity to be present without the benefit of fertility and for fertility to be present without elevated levels of maternal desire. As suckling behavior may depress fertility, it may also impact maternal sexual desires and behaviors. However, these changes may be only temporary, allowing infants an opportunity to elongate the effects, by timing them closely together.

Research on sexuality in breastfeeding mothers has been limited and little is known about variations in maternal sexuality during this period of time. The majority of studies focus on general sexual desire and function across women, but nothing is known about how desire and function fluctuate within a woman during this time. Similarly, nothing is known about the motivations behind maternal sexual behavior. This study was designed to learn more about within-mother variation in sexuality during lactation, comparing sexual desire and motivations immediately after breastfeeding to sexual desire and motivations several hours after a breastfeeding session. We also examine the potential for the partner relationship and fertility to influence motivations for engaging in sexual behavior.

It is predicted that (a) sexual desire will be lower in breastfeeding mothers immediately after a breastfeeding session than a few hours after a breastfeeding session, and (b) mothers in better relationships will report a different level of sexual desire, different levels of sexual activity, and different motivations for engaging in sexual activity than mothers in lower quality relationships.

Methods

Participants

Participants were 87 biological mothers of children between the ages of 2 and 7 months old. The mothers were a convenience sample recruited from online mother and breastfeeding groups/forums (whattoexpect.com, facebook.com, reddit.com). To participate, mothers needed to be the biological parent, living with the father, and in a relationship with the father of the child. In order to participate, mothers could not be using hormonal contraceptives pills or injections. Participants volunteered their time in exchange for raffle submissions for $25 (second, third, and fourth sessions) to $50 (initial and last session) gift cards to Target or Walmart. Participants were able to withdraw from the study at any time. Participants that did not complete the majority of in the initial session were removed from the data set (38 participants). Several mother had a child under the age requirement (2 participants with 4-week old infants) and were also excluded. Initial sessions were submitted for 49 mothers. Of those, 43 mothers agreed to be contacted for future sessions. Thirty-three of these mothers did the first follow-up session, 32 the second follow-up session, 27 the third follow-up session, and 23 mothers took the final follow-up session. Participants that missed a session were still sent invitations to participate in the remaining sessions. Some mothers missed a session or two, but. then came back to complete the remaining sessions. Of the mothers, 20 participated in all 4 follow-up sessions, 5 participated in three follow-ups, 8 participated in two follow-ups, and 4 participated in one follow-up. Thus, responses from 37 mothers were included in the analyses.

Participants ranged in age from 20 to 39 years old (M=28.71, SD=5.2) and reported the infants' fathers' ages ranging from 21 to 41 years old (M=30.2, SD=5.074). Mothers were mostly Caucasian (44 participants) and married (40 participants). All mothers were living with the father of their youngest child. Mothers reported working full time (20 participants), part time (10 participants), staying home (15 participants), and being home on parental leave (9 participants). Eight mothers were currently in school. Most mothers had their first child (32 participants) while others had two children (11 participants), three (3 participants), four (2 participants), and six (1 participants) children. Seventeen mothers reported a return to menstruation, while 31 had not started menstruating. Mother's BMI ranged from 17.57 to 41.20 (M= 27.566, SD=5.4996).

Infants ranged in age from 8 to 32 weeks (M=18.51 weeks, SD=5.66). Of the 49 infants, 20 were male and 29 were female. Most mothers exclusively breastfed (35 participants), while several other mothers had exclusively breastfeeding at one point (5 participants). Ten mothers reported supplementing breastmilk with formula, while 6 exclusively fed infants formula. Twelve infants had been introduced to solids foods. Infant birth weights ranged from 52 ounces to 157 ounces (M=115.65 ounces, SD=20.34 ounces).

Procedure

After obtaining informed consent, mothers were asked to complete a 30-minute general questionnaire on Opinio. The mothers were asked general and baseline questions about themselves, their youngest child, and their romantic relationship (both pre-pregnancy and during pregnancy). Then, participants were contacted four times across several weeks to complete 15-minute follow up sessions. For each follow-up sessions, participants were asked to fill out the Opinio questionnaire either in the morning or in the evening and either 20 minutes or 2 hours after feeding their infant. To control for order effects during the four follow-up sessions, the order of instructions was randomly assigned to participants using a random number generator. Participants answered screening questions at the beginning of each follow-up session to determine if they had followed the request. They were provided with instructions if their answers did not match the request (for example, "It is morning? Yes/No. If not, please come back and take this questionnaire tomorrow morning."). Session A (20 minutes, morning) had 26 participants. Session B (120 minutes, morning) had 27 participants. Session C (20 minutes, evening) had 32 participants. Session D (120 minutes, evening) had 30 participants.

Each subsequent questionnaire asked about the mother's ovulatory cycle (if menstruation started and the most recent menses) and questions about current sexual motivation, sexual behavior, sexual desire, and love/commitment. At the end of the last session, participants were asked follow-up questions (for example, "Did anything significant change in your romantic relationship during this study (partner was out of town, relationship ended, etc.)?") and debriefed.

Self-Report Measures

The majority of the questions used were modified versions of questionnaires used in previous research. Questionnaires were shortened to reduce fatigue, boredom, and attrition due to answering the same questions multiple times. Questionnaires were also modified to be sensitive to the time periods of interest (for example, current sexual motivation, instead of sexual motivation over the past month).

General information about mother. General information about the mother and her significant other were collected. This included the current date and time, recent activities, age, employment, education, relationship, family, ethnicity, income, general health, post-natal health, height, weight (pre-pregnancy and current), bra size (pre-pregnancy and current), hunger, exercise habits, ovulatory cycle information, and contraceptive use.

Time since breastfed. Mothers were asked to complete the questionnaire 20 minutes or 120 minutes after breastfeeding. During the session, mothers were also asked to report the last time they had breastfed and bottle-fed their infant. Mothers reported a variety of times since last feeding. These times did not always correspond exactly to the 20 or 120-minute categories, thus analyses were completed using the categorical groups (20 vs 120) and also using the continuous number of minutes since the participant last fed their infant. Figures 1 and 2 show the reported times since last feeding for the 20 minute and 120 minute categories.

Psychological Health. The Center for Epidemiologic Studies Depression Modified 4-item scale (CES-D) (original scale Radloff, 1977; 4-item scale Melchior, Huba, Brown, & Reback, 1993) was used to assess depression. Responses were summed to measure depression and ranged from 4 to 15 (M=7.51, SD=2.69). One 7-level question was used to assess anxiety (How much of the time during the past 4 weeks did you feel anxious or worried?)(M=3.84, SD=1.80).

Fatigue. Fatigue and sleep were measured for the participants, as they may be related to lower sexual desire and less sexual behavior in new mothers. Two questions taken from the fatigue related items in the Sf-V36 Vitality Scale (Ware, Kosinski, &

Keller, 1994) were used on the initial questionnaire ("How much of the time during the last four weeks did you have a lot of energy" and "How much of the time during the last four weeks did you feel worn out"). The energy question was reverse-scored and responses were summed to measure fatigue points out 14 (M=9.06, SD=1.93). Sleep was measured using several questions from the Sleep Scale for the Medical Outcomes Study (Hays & Stewart, 1992) with the addition of questions about night time wake ups (number and length).

General Information about Partner. Participants were asked about their partner's age; height; weight; education; employment; income; and time spent doing infant care.

Partner's Attractiveness. Participants were asked to rate their partner's attractiveness. Questions about attractiveness came from previous research (Larson, Pillsworth, & Haselton, 2012) with the addition of two questions (rating partner's intelligence and how funny they are). Principal component analysis of the four responses to partner attractiveness yielded a single component accounting for 59.309% of the variance in measures; scores on this component were calculated based on a regression method. The Kaiser-Meyer-Olkin measure of sampling adequacy was fine (0.646).

General information about child of interest. General information about the participant's youngest child was collected. This included birth weight; age; pregnancy or birth complications; sleep habits; who cares for them; and eating habits (including breastfeeding, formula; solids, and pumped milk).

Relationship satisfaction. A modified version of the Perceived Relationship Quality Components Inventory (Fletcher, Simpson, & Thomas, 2000) was used to assess relationship satisfaction and quality. Participants were asked to assess their relationship pre-pregnancy, during pregnancy, and currently. Principal component analysis was used to calculate a single component from six relationship responses using a regression method. The component accounted for 56.541 % of the variance. The Kaiser-Meyer-Olkin measure of sampling adequacy was fine (0.790).

Sexual desire. Current sexual desire was measured using one question ("I had strong feelings of sexual desire"). Current extra-pair and in-pair sexual desire were also measured. Sexual desire was also measured retrospectively for pre-pregnancy and during pregnancy. These questions were used in previous research (Grebe et al., 2016).

Principal component analysis was used to reduce the number of sexual desire responses before conducting analysis. Two components emerged using Promax rotation in the initial analyses. Component 1 accounted for 40.498% of the variance and component 2 accounted for 21.959% of the variance (Keyser-Meyer-Olkin=0.710). One question was removed due to poor loading onto both components. Analyses were run again using Promax rotation and composite scores were computed for in-pair and extra-pair sexual desire using the regression method. Component 1, extra-pair sexual desire, then accounted for 41.580% of the variance and component 2, in-pair sexual desire, accounted for 25.529% of the variance (Keyser-Meyer-Olkin=.673)(See Table 1). Extra-pair sexual desire was low in the entire sample. "Not at all" or 0 responses were recorded for the questions related to extra-pair desire between 81.3% of the time [I will feel sexually aroused by the sight of a very physically attractive person (not my current partner)] and 92.5% of the time (I will feel strong attraction toward someone other than a current partner).

Sexual activity. Participants were asked about the frequency of sexual intercourse pre-pregnancy, during pregnancy, and currently (e.g. "On average, how many times a week did you engage in sex during your pregnancy?"). Participants were asked about who initiated sexual intercourse (pre-pregnancy, during pregnancy, and currently) (e.g. "On average, how many times a week did you initiate sex during your pregnancy?"). They were also asked about the most recent sexual intercourse (e.g. "When was the last time you engaged in sexual activity?").

Sexual activity ranged from 0 to 35 times a week pre-pregnancy (M=3.69; SD=5.320) to 0 to 22 times a week during pregnancy (M=2.45; SD=2.45). Mothers reported initiating sex anywhere from 1 to 22 times a week pre-pregnancy (M= 2.45, SD=4.427) to 0 to 12 times a week during pregnancy (M=.94, SD=2.004). Sexual activity during the postpartum follow-up sessions ranged from 0 to 5 times per week (M= 1.25, SD =1.045), with mothers initiating sex 0 to 3 times a week (M=.73; SD=.869), and the partner initiating 0 to 20 times a week (M=1.16, SD=2.338).

Sexual motivation. A modified version of Meston and Buss (2013) YSEX Questionnaire was used to assess sexual motivations. The questions were limited to those of the most interest in this study. Participants were asked about sexual motivations pre-pregnancy, during pregnancy, in the last week, and currently. Questions addressing pleasure and duty were reverse-scored, so that all responses loaded in the same direction.

Principal component analysis using Promax rotation was used to split sexual motivation questions into components. Two components emerged (Keyser-Meyer-Olkin=0.838). Component 1 accounted for 51.340% of the variance and component 2 accounted for 18.782% of the variance. One response, asking about partner-satisfaction, loaded similarly onto both components and was excluded from the analyses. Principal component analysis was run a second time (see Table 2). The components were rotated and composite scores were calculated using the regression method (Keyser-Meyer-Olkin=0.879). Composite score 1, partner-bonding motivations accounted for 62.750% of the variance. Composite score 2, pleasure vs duty-related motivations (4 scores) accounted for 15.712 % of the variance.

Sexual function. Sexual function was measured using a shortened version of the Female Sexual Function Index (Rosen et al., 2000). The questions cover sexual desire, lubrication during intercourse, orgasm, pain, and satisfaction.

Analyses

To test our hypotheses, random-intercept restricted maximum likelihood generalized linear mixed-models (GLMM) analyses were run using IBM SPSS Statistics version 25 (IBM Corp 2017). Analyses were run on both sets of composite variables related to desire (in-pair desire and extra-pair desire) and sexual motivations (partner-connection, partner-need, and pleasure-related), as well as on the frequency of sexual activity. All analyses included the random-intercept nested within participant as a random effect. Time of day was not significant for any analyses. Some GLMM analyses were run separately using nominal groups of "20 minutes after fed" vs "120 minutes after fed" or using the continuous variable "minutes since last fed." The nominally grouped variable is referred to as "time since fed," whereas the continuous variable is referred to as "minutes since fed."

Results

Preliminary analyses

GLMM was used to determine if breastfeeders differed from non-breastfeeders in fatigue levels and BMI. No significant results were found. Though fatigue did not differ significantly between breastfeeders and non-breastfeeders, it was included in initial models as a potential predictor for reduced sexual desire, motivation, and behavior. GLMM using was also used to check for order effects. No significant effects of order were detected.

A bivariate Pearson correlation was computed for the nominally grouped time variable “time since fed” and the continuous time variable “minutes since last fed,” $r=0.605$, $n=110$, $p<0.000$.

Sexuality in Breastfeeders

Sexual desire. To test whether in-pair and extra-pair sexual desire were lower shortly after breastfeeding and to determine if in-pair and extra-pair desire were related to relationship quality, restricted maximum likelihood GLMMs were run selecting only the cases where a mother was currently breastfeeding her child (n=80). This set of cases included mothers who supplemented breastfeeding by using formula. It excluded cases where the mother bottle-fed breastmilk or formula (n=30). Analyses for both in-pair and extra-pair sexual desire were initially run using the time since breastfed, current relationship quality, infant age, and all interactions as both fixed effects and as random effects nested under participant. Time of day was also included as both a random and fixed effect and fatigue was included as a fixed factor. The random intercept for mothers was included as a random effect.

Table 3 displays the GLMM summary for models of in-pair and extra-pair sexual desire using time since breastfed. Time since breastfed was significant as a predictor of in-pair sexual desire, F(1, 66)=4.07, coefficient=-0.331, p=0.048. The three way interaction between relationship quality, time since breastfed, and infant age was marginally significant, F(1,66)=2.91, coefficient=-0.480, p=0.093. Relationship quality had a greater positive impact on in-pair sexual desire for mothers of older infants, 120 minutes after breastfeeding, than 20 minutes after breastfeeding. The in-pair sexual desire model was run a second time removing the fatigue and time of day as fixed effects and all random effects, except the random intercept for mothers. Time since breastfed was a marginally significant as a predictor, F(1, 68)=3.38, coefficient=-0.283, p=0.070 and the three-way interaction remained marginally significant, F(1, 68)=2.89, coefficient=-0.348, p=0.093. For extra-pair sexual desire, infant age was a significant predictor, F(1,66)=7.56, p=.008 (coefficient=-0.305, p=0.119). The extra-pair sexual desire model was run a second time removing all random effects (except the random intercept for mothers) and removing time of day, the relationship quality x time since fed interaction, time since fed x infant age interaction, and the three-way interaction. Relationship quality, F(1, 70)=6.38, coefficient=-0.332, p=0.014, infant age, F(1, 70)=10.9, coefficient=-0.413, p=0.002, and the relationship quality by infant age interaction, F(1, 70)=4.48, coefficient=0.286, p=0.038 were significant predictors of extra pair sexual desire. The negative relationship between extra-pair sexual desire and relationship quality was stronger when infants were younger.

A second set of GLMM were run for both in-pair and extra-pair desire including minutes since breastfed in place of time since breastfed. Thus, minutes since breastfed, current relationship quality, infant age, and all interactions were included as fixed effects and were nested under participant as random effects. Infant age was included as a fixed and random effect. Fatigue was also included as a fixed effect. Table 4 displays the summary for models of in-pair and extra-pair sexual desire using minutes since breastfed as a predictor. There was a significant interaction between relationship quality and minutes since breastfed, $F(1, 66)=4.02$, coefficient=-0.490, $p=0.049$. There were also marginally significant effects of the three-way interaction between relationship quality x minutes since breastfed x infant age interaction, $F(1, 66)=3.26$, coefficient=0.531, $p=0.076$, and the main effect of fatigue, $F(1, 66)=3.05$, coefficient=-0.112, $p=0.085$. The model was run a second time without time of day as a fixed effect and without the random slope effects (but including the random intercept). Fatigue no longer had a marginally significant main effect, but infant age did, $F(1, 67)=3.70$, coefficient=-0.330, $p=0.059$. The interaction between relationship quality and minutes since breastfed, $F(1, 67)=2.84$, coefficient=-0.384, $p=.097$, and the interaction between minutes since breastfed and infant age, $F(1, 67)=2.83$, coefficient=-0.266, $p=0.097$ approached significance. The three way interaction between relationship quality, infant age, and minutes since breastfed, $F(1, 67)=2.83$, coefficient=0.441, $p=0.097$, still approached significance.

The same model was run to predict extra-pair sexual desire. Only infant age significantly predicted extra-pair sexual desire, $F(1, 66)=4.63$, coefficient=-0.333, $p=0.035$. Relationship quality was a marginally significant predictor of extra-pair sexual desire, $F(1, 66)=3.21$, coefficient=-0.286, $p=0.078$. The analyses was run a second time using relationship quality, minutes since breastfed, infant age, minutes since breastfed by infant age, and relationship quality by infant age as a fixed effects and the random intercept as a random effect. Infant age remained a significant predictor, $F(1, 70)=9.54$, coefficient=-0.391, $p=0.003$). Relationship quality, $F(1, 70)=7.11$, coefficient=-0.352, $p=0.010$, and the relationship quality by infant age interaction, $F(1, 70)=5.39$, coefficient=0.315, $p=0.023$, became significant predictors of extra-pair sexual desire.

Sexual Motivation. Both sexual motivations were tested to determine if recent breastfeeding and relationship quality differentially predicted motivations. The initial model, found in Table 5, included time since breastfed, current relationship quality, infant age, and all interactions between them fixed and random factors. In pair sexual desire and time of day were also included as both fixed and random factors and fatigue was included as a fixed factor. The model was also run with the removal of in-pair sexual desire as a predictor, due to the relationship between relationship quality and in-pair sexual desire. These results can be found in Table 6. Another model, found in Table 7, was tested substituting minutes since breastfed in place of time since breastfed groups (20 minutes after breastfeeding and 120 minutes after breastfeeding). All initial models started the same, then were pared down to cut out insignificant predictors. As relationship quality and time since breastfed were potential predictors of in-pair sexual desire, a separate model was tested without in-pair sexual desire (Table 8 contains the model summary without in-pair sexual desire). All initial models started the same, then were pared down to cut out insignificant predictors.

In-pair sexual desire was a significant predictor of pleasure-related sexual motivation $F(1, 60)=6.24$, coefficient=0.278, $p=.015$. The three-way interaction between relationship quality, time since breastfed, and infant age was also a significant predictor, F(1, 60)=7.01, coefficient=0.417, p=0.010. Relationship quality had a more impact on pleasure-related sexual motivations for mothers of older infants, twenty minutes after breastfeeding than 120 minutes after breastfeeding or for mothers of younger infants. The fixed effects of time of day and all random-slopes effects (except the random intercept) were removed and the model was run a second time. In-pair sexual desire remained a significant predictor F(1, 61)=6.16, coefficient=0.249, p=0.016, as did the three-way interaction, F(1, 61)=4.40, coefficient=0.335, p=0.040. All other fixed effects were not significant. When the model was tested without in-pair sexual desire and time of day, the three way interaction was only marginally significant, F(1, 63)=2.94, coefficient=0.275, p=0.091. The model was also tested using minutes since breastfed instead of the time since breastfed (20 minutes and 120 minutes). In pair sexual desire was the only significant predictor, F(1, 61)=6.07, coefficient=0.245, p=0.017.

Motivations to connect with one's partner was significantly predicted by in-pair sexual desire, F(1, 60)=5.99, coefficient=0.384, p=0.017). The time since breastfed by infant age interaction was a marginally significant predictor, F(1, 60)=3.24, coefficient=0.264, p=0.077. Partner-connection sexual motivations were lower in mothers with younger infants than older infants 20 minutes after breastfeeding, but not 120 minutes after breastfeeding. The model was trimmed to remove all random effects, except the random intercept and the time of day, the relationship quality by time since breastfed interaction, relationship quality by infant age interaction, and relationship quality by time since breastfed by infant age interaction as fixed effects. Current relationship quality was a significant predictor of partner-connection sexual motivations, F(1, 64)=5.34, coefficient=0.283, p=0.024. In-pair sexual desire was marginally significant, F(1, 64)=3.97, coefficient=0.219, p=0.051 and the infant age by time since breastfed interaction was also marginally significant, F(1, 64)=3.77, coefficient=0.287, p=0.057. When the model was run excluding in-pair sexual desire, relationship quality remained a significant predictor, F(1, 65)=5.71, coefficient=0.298, p=0.020 and the infant age by time since breastfed interaction was significant, F(1, 65)=4.51, coefficient=0.316, p=0.038. When minutes since breastfed was substituted for time since breastfed, only in-pair sexual desire was a significant predictor of partner-connection sexual motivation, F(1, 60)=5.52, coefficient=0.363, p=0.022. The minutes since breastfed by infant age interaction was marginally significant, F(1,64)=3.54, coefficient=-0.279, p=0.059. The model was trimmed to remove time of day, the three-way interaction between relationship quality, minutes since breastfed, an infant age, the minutes since breastfed by relationship quality interaction, and the relationship quality by infant age interaction as fixed effects. All random effects were removed except for the random-intercept. Relationship quality, F(1, 64)=4.01, coefficient=0.213, p=0.050 and in-pair sexual desire, F(1, 64)=5.50, coefficient=0.357, p=0.022 were significant predictors of partner-connection sexual motivations. The minutes since breastfed by infant age interaction was also significant, F(1, 65)=8.49, coefficient=-0.281, p=0.005. The random effect of in-pair sexual desire was also marginally significant using minutes since breastfed as a predictor, estimate=0.248, SD=0.135, Z=1.83, p=0.067. When in-pair sexual desire was removed, the results were similar, though in-pair sexual desire was no longer a predictor.

Frequency of Sex. A model of frequency of sexual activity in breastfeeders was tested using current relationship quality, fatigue, partner attractiveness, infant age, and in-pair sexual desire as fixed effects (see Table 9 for model summary). Current relationship quality, in-pair sexual desire, and infant age were included as random effects under participant. In-pair sexual desire was a significant predictor, $F(1, 72)=8.64$, coefficient=0.315, $p=.004$. All other fixed and random effects were not significant.

Breastfeeders pleasure-related and partner-connection sexual motivations were included in a separate model of frequency of sexual activity (see Table 10 for model summary). Sexual motivations were not significant predictors of the frequency of sex in breastfeeders.

Sexuality and Relationship Quality

Sexual desire. To test whether sexual desire was higher in mothers with better relationships, restricted maximum likelihood linear mixed models were run using all cases. The initial model summary for both in-pair and extra-pair desire can be found in Table 11. Fatigue, current relationship quality, partner attractiveness, resumption of menstruation, infant age, and time of day were included as fixed effects, with current relationship quality, infant age, and time of day nested under participant as a random effect.

Using the initial model there were not any significant fixed or random predictors of in-pair sexual desire. Infant age was a marginally significant predictor, $F(1, 99)=3.88$, coefficient=-0.283, $p=0.052$. Partner attractiveness, resumption of menstruation, time of day, and the random-slope effects were removed from the model. The random-intercept remained in as a random predictor. In the trimmed model, infant age was a significant predictor of in-pair sexual desire, $F(1, 102)=4.02$, coefficient=-0.283, $p=0.048$.

Extra-pair sexual desire was tested using the same initial model. Relationship quality, $F(1, 99)=4.50$, coefficient=-0.260, $p=0.036$), resumption of menstruation, F(1, 99)=6.83, coefficient=-0.465, p=0.010, and infant age, F(1, 99)=11.4, coefficient=-0.295, p=0.001 were significant predictors of extra-pair sexual desire. Partner attractiveness, time of day, and the random-slope effects were. removed from the model. All other predictors and the random intercept for mothers remained in the model. Relationship quality, F(1, 101)=5.32, coefficient=-0.212, p=0.023, fatigue, F(1, 101)=4.53, coefficient=-0.096, p=0.036, resumption of menstruation, F(1, 101)=5.94, coefficient=-0.463, p=0.017, and infant age, F (1, 101)=10.6, coefficient=-0.297, p=0.002 were significant predictors of extra-pair sexual desire.

Sexual Motivations. Motivations for engaging for sex were tested to determine if relationship quality predicted different motivations. The initial model for each sexual motivation included current relationship quality, fatigue, partner attractiveness, resumption of menstruation, in-pair sexual desire, infant age, and time of day as fixed factors. In-pair sexual desire, current relationship quality, infant age, and time of day were included as random factors under participant. Table 12 contains the initial and trimmed model summaries for sexual motivation. A separate set of analyses looked at extra-pair sexual desire as a predictor of both sexual motivations (Table 13). It did not significantly predict either.

In the initial model of pleasure-related sexual motivation, in-pair sexual desire was a significant predictor, F(1, 93)=5.45, coefficient=0.174, p=0.022. Infant age and partner attractiveness were far from significance and were removed from the model along with the random-slope factors. The random intercept for mothers remained. In-pair sexual desire remained a significant predictor of pleasure-related sexual motivation in the trimmed model, F(1, 95)=5.98, coefficient=0.182, p=0.016).

Relationship quality, F(1, 93)=11.9, coefficient=0.336, p=0.001, partner attractiveness, F(1, 93)=4.29, coefficient=0.259, p=0.041, resumption of menstruation, F(1, 93)=5.98, coefficient=-0.439, p=0.016, and in-pair sexual desire, F(1, 93)=7.50, coefficient=0.274, p=0.007, were significant predictors of partner-connection sexual motivation. Fatigue, infant age, and the random slopes effects were removed from the model, though the random intercept remained in. In the trimmed model, relationship quality, partner attractiveness, and in-pair sexual desire were again significant predictors. Resumption of menstruation became a marginally significant predictors, F(1, 95)=3.82, coefficient=-0.364, p=0.054.

Frequency of sex. Frequency of sexual activity was tested using current relationship quality, in-pair sexual desire, partner attractiveness, fatigue, resumption of menstruation, and infant age as fixed effects, while in-pair sexual desire, current relationship, and infant age were included as random effects (see Table 9). In-pair sexual desire was a significant predictor of sexual frequency, F(1, 97)=6.39, coefficient=0.262, p=0.013, and resumption of menstruation was marginally significant, F(1, 97)=2.99, coefficient=0.458, p=0.087. Fatigue and partner attractiveness and the random-slopes effects were far from significance and were removed from the model, though the random intercept for participants remained in. In-pair sexual desire stayed a significant predictor, F(1, 99)=5.85, coefficient=0.259, p=0.017, however resumption of menstruation was no longer marginally significant. In a separate GLMM, extra-pair sexual desire did not significantly predict frequency of sex (Table 13).

Frequency of sexual activity was also tested used the pleasure-related and partner-connection motivations for sexual activity as predictors (see Table 10). Pleasure-related sexual motivation was a marginally significant predictor, F(1, 97)=2.97, coefficient=0.245, p=0.088. As this differed from breastfeeders, where no measured sexual motivations predicted sexual frequency, pleasure-related sexual motivation, type of feeding, and the interaction between pleasure-related sexual motivation and type of feeding were included in a separate model of frequency of sex (Table 14). Pleasure-related sexual motivation and the interaction were included as fixed and random factors. Type of feeder was included as a fixed factor and the random intercept for mothers was included. Type of feeding was a significant predictor of frequency of sex, F(1, 96)=6.02, coefficient=0.657, p=0.016.

Sexuality Differences in Breastfeeders and Bottle-feeders

Time since fed by feeding type.

Sexual desire. A GLMM tested the differences in in-pair and extra-pair desire using time since fed, type of feeding, infant age, and their two-way and three-way interactions as fixed and random predictors. There was a significant interaction between time since breastfed and type of feeding (breastfeeding vs. bottle-feeding) as a predictor of in-pair sexual desire, F(1, 98)=6.62, coefficient=0.737, p=0.012. Mothers that breastfed reported lower in-pair sexual desire 20 minutes after breastfeeding, than 120 minutes after breastfeeding. Bottle-feeding mothers showed a pattern in the opposite direction, lower in-pair sexual desire 120 minutes after breastfeeding, than 20 minutes after breastfeeding. Infant age had a marginally significant main effect, F(1, 98)=3.74, coefficient=-0.296, p=0.056. When “minutes since fed” was substituted for “time since fed,” infant age had a significant main effect, F(1, 98)=5.98, coefficient=-0.358, p=0.016. Minutes since fed, type of feeding, and infant age had a significant three-way interaction, F(1, 98)=4.19, coefficient=0.429, p=0.043. The two-way interaction between type of feeding and minutes since breastfed was marginally significant, F(1, 98)=3.45, coefficient=-0.408, p=0.066. Table 15 displays the model summary. In the model looking at extra-pair sexual desire, infant age was a significant predictor of extra-pair sexual desire when "time since fed" was used as a variable, F(1, 98)=6.24, coefficient=-0.199, p=0.014 and when "minutes since fed" was used as a variable, F(1, 98)=5.82, p=0.018 (coefficient=-0.366, p=0.007).

Sexual Motivation. Generalized linear mixed models were run to test the fixed effects and random effects of time since fed, type of feeding, infant age and their interactions (Table 16). All fixed and random factors were not significant for pleasure-related motivations using both "time since fed" and "minutes since fed." The three way interaction between time since fed, type of feeding, and infant age was significant for partner-connection sexual motivations, F(1, 94)=5.12, coefficient=-0.502, p=0.026. Twenty minutes after feeding, infant age was less negatively associated with partner-connection sexual motivations for breastfeeders compared to bottlefeeders. This three-way interaction was also significant when "minutes since fed" was used in place of "time since fed," F(1, 94)=6.89, coefficient=0.420, p=0.010.

Discussion

Breastfeeding Recency

The hypothesis that recent breastfeeding would reduce sexual desire was partially supported by the data. Breastfeeding recency influenced in-pair desire, but not extra-pair desire. Twenty minutes after breastfeeding in-pair desire was lower than 120 minutes after breastfeeding, suggesting that breastfeeding may temporarily depress in-pair sexual desire. This supports the idea that infants could possibly influence maternal sexuality through breastfeeding behaviors. If an infant were to feed often, maternal in-pair sexual desire could be kept consistently low. When minutes since breastfed was included as a continuous variable, in place of time since breastfed, the main effect of breastfeeding recency lost significance. Thus, the impact of breastfeeding recency on in-pair sexual desire needs further clarification. It is unclear why the main effect of timing is no longer significant when using minutes since breastfed, though it is possible that the minutes since breastfed do not linearly predict in-pair sexual desire.

Importantly, extra-pair sexual desire did not vary depending on the recency of breastfeeding. During lactation, studies have shown that sexual desire and the frequency of sexual activity are low (Ahlborg, et al., 2005; Barret et al., 2000; LaMarre et al., 2003; Malakoti et al., 2013; Von Sydow, 1999). The lower overall level of sexual desire and frequency may create a “floor effect” for extra-pair desire. As extra-pair desire is already near zero during this time, it may not possible for it to drop lower in response to suckling. This reduced variability in extra-pair desire between sessions 20 minutes after breastfeeding and 120 minutes after breastfeeding makes detection of any existing effect difficult. Thus, this study was not able to distinguish whether breastfeeding suppresses extra-pair desire or whether extra-pair desire is not affected by breastfeeding.

Extra-pair and in-pair desire might be governed by different mechanisms due to situational factors differentially predicting the benefits and risks of each. In breastfeeders, the probability of conception is low and thus, sexual activity during lactation is likely for other purposes, such as maintaining partner interest. Thus, some in-pair sexual desire during lactation would be expected. On the other hand, the unlikeliness of conception means sexual activity with an extra-pair partner during lactation would have little benefit. Additionally, extra-pair sexuality activity has higher risks for mothers with young children. Sex with a non-partner brings the risk of losing a provisioning partner without the guarantee of provisions from a new partner, as well as the potential physical danger of a new partner to the mothers' existing offspring (Fujiwara, Barber, Schaechter, & Hemenway, 2009; Naidoo, 2000). Thus, depressed levels of extra-pair sexual desire during lactation would also be expected. Mothers may be best served by a steady state of low extra-pair sexual desire, evidenced by the frequency of 0 responses.

Support was found for variation in maternal levels of in-pair sexual desire in response to breastfeeding recency. This variation may reflect maternal efforts to achieve balance between parental energy and relationship maintenance energy allocation. As extra-pair sexual desire remained low but in-pair sexual desire increased in the time since breastfeeding, extra-pair sexual desire may be constrained although in-pair desire is permitted to fluctuation. A breastfeeding mechanism may modulate the shift from in-pair mating effort to parenting effort. Infants able to manipulate this mechanism to reduce in-pair sexual desire may benefit by lengthening the interbirth interval.

Female sexual desire is complicated and relies on more than physical reactions. Cues leading to sexual desire in females have been grouped into four categories: emotional bonding, explicit/erotic, visual/proximity, and romantic/implicit cues (McCall & Meston, 2006). It is likely that extra-pair desire may rely more on the objective and physical cues corresponding to those falling within explicit/erotic and visual/proximity. In-pair desire assumes some level of pair- bonding and would be expected to utilize the same cues as extra-pair desire, but also encompass the more subjective emotional and social cues. Extra-pair sexual desire then, may be more dependent than in-pair sexual desire on cues that could be altered by metabolic load. Consequently, it may be possible for mothers to experience increases or decreases in the levels of in-pair desire when their energy balance is low, despite no corresponding fluctuation in extra-pair desire.

Research has also found that the hormone profiles may be different for extra-pair and in-pair desire (Grebe et al., 2016), though at least one study has not confirmed this difference (Roney & Simmons, 2016). The stimulation or suppression of these hormones during breastfeeding may be related to the changes in in-pair sexual desire. Estrogen may be positively associated with extra-pair sexual desire and negatively associated with in-pair desire. Progesterone may be associated with higher in-pair sexual desire. During lactation progesterone and estrogen levels are both low (Dada & Laditan, 1982; Joshi et al. 1980). The low estrogen may uniformly decrease extra-pair desire. Yet, estrogen and progesterone appear to be at odds in their associations with in-pair sexual desire. As low estrogen is associated with higher in-pair desire and low progesterone is associated with lower in-pair desire, in-pair desire might change if the balance between progesterone and estrogen shift during lactation. High levels of estrogen may negatively impact lactation, but progesterone does not, as indicated by studies on birth control methods during lactation (Diaz & Croxatto, 1993; Kochenour, 1980). Thus, estrogen increases (and corresponding change in extra-pair desire) are not likely during lactation. Progesterone though, may have slight increases without hurting milk production. Changes in estrogen and progesterone should be examined in association with suckling and maternal metabolic load. Further research should also investigate the relationship between extra-pair desire, in-pair desire, estrogen, progesterone, and the cues of female sexual desire to determine if they are related during the lactational period.

Interaction between feeding recency and type of feeding. Support for an interaction between timing of feeding and type of feeding (breast vs bottle) was found for in-pair sexual desire, but not for extra-pair desire, pleasure-related sexual motivation, partner-need sexual motivation, or partner-connection sexual motivation. Breastfeeders reported lower in-pair sexual desire 20 minutes versus 120 minutes after feeding their infant. Bottle-feeders reported the reverse (higher in-pair sexual desire 20 minutes after bottle-feeding than 120 minutes). However, these analyses were constrained by the limited number of bottle-feeders in the study for comparison. When the continuous "minutes since breastfed" was used, the interaction between breastfeeding recency and type of feeding was only marginally significant, though the three-way interaction between feeding recency, type of feeding, and infant age became significant. Further study of this interaction needs a much larger sample size. It may also be beneficial to compare breast and bottle-feeders with samples of nulliparous women and women with older children. Such comparisons would provide information on how maternal energy allocations within mating effort shift with the presence of young children and if they shift back as children age.

Relationship Quality

Breastfeeders. Some support was found for the hypothesis that relationship quality impacts sexual desire and motivations. In analyses using minutes since breastfed, breastfeeders in higher quality relationships reported less extra-pair sexual desire, than those in higher quality relationships. This effect was stronger in mothers with younger infants (though this may be due to the overall low reports of extra-pair sexual desire). In breastfeeders, no main effect of relationship quality was found on in-pair sexual desire. However, relationship quality may differentially impact the interaction between infant age and breastfeeding recency on in-pair sexual desire. When relationship quality is low, the negative impact of infant age and breastfeeding recency on in-pair sexual desire are stronger. Further studies need to be done to clarify the uncertain results on whether relationship quality interacts with breastfeeding recency and infant age.

Relationship quality did not predict the frequency of sexual activity in breastfeeders indicating that breastfeeders engage in the same frequency of sex, regardless of relationship quality, but do so for different reasons. As expected, relationship quality was linked with partner-connection sexual motivations in breastfeeders. Mothers in good relationships may increase fitness benefits through simultaneous investment into their relationship and offspring where those in poor quality relationships have little to gain through continued relationship investment. Despite their temporary infertility and low sexual desire, breastfeeders may be motivated to have sex with their partner during lactation as a continued long-term investment into their quality relationship, as evidenced by their higher reports of partner-connection sexual motivation. In contrast, those in poor quality relationships may simply shift energy allocation toward their offspring and invest little into maintaining their relationship.

Relationship quality did not have an overall main effect on pleasure-related sexual motivations, but may interact with breastfeeding recency and infant age to predict pleasure-related sexual motivations. High-quality relationships may have a more positive impact on pleasure-related sexual motivations 20 minutes after breastfeeding, than 120 minutes after breastfeeding in mothers feeding older infants.

All mothers. The impact of relationship quality on maternal sexuality was also investigated for all new mothers in the sample, including those that formula-fed and those that pumped exclusively. In the inclusive sample, current relationship quality did not predict in-pair sexual desire, though the data shows a trend in the correct direction. Current relationship quality did significantly predict extra-pair desire. Mothers in lower quality relationships reported more extra-pair sexual desire.

Current relationship quality did not predict the frequency of sexual activity. However, as with breastfeeders, mothers in higher quality current relationships reported more partner-connection sexual motivations. Pleasure-related sexual motivation was unrelated to relationship quality. While similar to the breastfeeding sample, the association between relationship quality and partner-connection sexual motivation is clearer in the inclusive mother sample.

Age

As infants grow their caloric demands increase, as do the energetic costs of milk production (Butte, Lopez-Alarcon, Garza, 2002) until the mother introduces supplemental foods into the infant's diet. If maternal sexual desire is influenced by metabolic load, one would expect overall decreases in sexual desire as the infant ages. Evidence for this change in desire was found in this study. Both extra-pair and in-pair sexual desire were lower in breastfeeding mothers of older infants. The impact of infant age on sexual desire would also be expected to be higher in breastfeeding mothers. However, lower extra-pair and in-pair sexual desire was also found in the mothers of older children within the inclusive sample (including bottle-feeders) and there was not a significant infant age by feeding type interaction.

Opposingly, some maternal hormone responses to breastfeeding, like prolactin release, are greater in mothers of younger infants (Johnston & Amico, 1986). If changes in sexual desire are due to the release of hormones like prolactin, breastfeeding recency would be expected to have a greater impact on sexual desire in mothers of younger infants and infant age would be expected to have a positive relationship with sexual desire (higher levels of sexual desire reported as the infant ages). Yet, both in-pair and extra-pair sexual desire were significantly lower in mothers of older infants in this study and there was not a significant interaction between breastfeeding recency and infant age. After about two or three months the basal levels of prolactin fall as do the suckling related prolactin peaks (Hill, Chatterton, Aldag, 1999). Prolactin is still stimulated in response to suckling, however it is released in lower amounts. The sample for this study included mothers of infants ages 2 months to 7 months, placing most mothers into the mid-lactation stage (lactation is well-established and weaning has not started). While the prolactin releases during breastfeeding are higher during mid-lactation than late lactation

(Johnston & Amico, 1986), it may be that there is little variation in the prolactin suckling response over time within this stage of lactation.

The three-way interaction between recency of feeding, type of feeding, and infant age was significant for partner-connection sexual motivation (as was the time since breastfed by infant age interaction for breastfeeders). In breastfeeders, partner-connection motivations were lower in for mothers of older infants 120 minutes after breastfeeding compared to 20 minutes after breastfeeding. Oxytocin, a bonding hormone released in response to breastfeeding (Numan & Young, 2016; McNeilly et al., 1983), may be impacting maternal motivations to connect with their partner with bonding.

Fatigue

One possible reason for the differences in sexuality reported between breastfeeders and non-breastfeeders is physical exhaustion. While all mothers of young children experience fatigue, breastfeeders are thought to experience higher levels due to the energetic costs of milk production and the possibility of less sleep and more sleep interruptions. Thus, maternal fatigue may impact overall metabolic load, lessening the available energy for relationship investment. This is could be a possible cause of lower sexual desire in breastfeeding mothers. To test this possibility, fatigue was included as an initial predictor in models of breastfeeding sexual desire and motivation. Fatigue was not a significant predictor of in-pair or extra-pair sexual desire in breastfeeders, though its removal from the model did reduce the significance of at least one other predictor of in-pair sexual desire. Fatigue was also not a significant predictor of the frequency of sexual activity or the two sexual motivations measured in breastfeeders. In the complete sample, fatigue did predict extra-pair sexuality. More fatigued mothers indicated lower extra-pair sexual desire. If extra-pair sexual desire is more sensitive to maternal energetic status, a relationship between fatigue and extra-pair desire would be expected. Yet, a similar significant association was not found in breastfeeders. This may be due to the near zero levels of extra-pair desire.

Resumption of Menstruation

Resumption of menstruation was also included in as a predictor to determine if a mothers' return of fertility was related to sexual desire or sexual motivations. Resumption of menstruation did not predict in-pair sexual desire but did predict extra-pair sexual desire in the inclusive mother sample. This is supportive of previous research that maternal sexual desire stays low even after the end of lactation amenorrhea (Alder, 1989) and research showing that the resumption of menstruation is associated with improved maternal sexuality (Escasa-Dorne, 2015; Khajehei et al., 2015). The higher levels extra-pair desire, but unchanged in-pair desire in the cycling group may correspond with research showing hormone associations with in-pair and extra-pair sexual desire (Grebe et al., 2016), as well as the possibility that extra-pair sexuality may be more sensitive to maternal metabolic load. The preceding increase in energy balance or the increase in estrogen that accompanies ovulation may account for the relationship between resumption of ovulation and extra-pair desire.

Resumption of menstruation also predicted more partner-connection sexual motivation and a higher frequency of sexual activity, but not pleasure-related sexual motivation. The positive energy balance that accompanies the return to fertility, as well as the return to fertility itself, may correspond with other physiological changes that may lead aspects of sexual interest to be higher (like the resumption of hormonal ovulatory cycle changes, though the ovulatory cycle does not return to nulliparous levels- Barrett, Parlett, Windham, & Swan, 2014). It important to note that the influence of resumption of menstruation on maternal sexuality is confounded by the age of the infant (older infants are more likely to have mothers that are cycling) and by breastfeeding (as breastfeeding infants are less likely to have mothers that are cycling).

Sexual Desire

In breastfeeders and the all-mother sample, in-pair sexual desire was a significant predictor of many aspects of maternal sexuality. Due to postpartum amenorrhea, sexual activity during the post-natal period is not for conceptive purposes. Instead, maintenance of the pair-bond relationship assumed to be the primary motivation for sexual activity. Consequently, in-pair sexual desire, but not extra-pair desire, would be anticipated to predict the frequency of sexual activity and sexual motivations during lactation. Pleasure-related sexual motivation, partner-connection sexual motivation, and the frequency of sex were predicted by in-pair sexual desire in both breastfeeders and the all-mother sample. Extra-pair sexual desire did not predict any sexual motivations or the frequency of sex.

Intra-Mother Variation in Sexuality

Little evidence addressing within-mother differences in sexuality fluctuations was found. The association between in-pair sexual desire and partner-connection sexual motivations may vary across breastfeeders. The low levels of maternal sexual desire and motivation during lactation and new motherhood may reduce the amount of detectable variation. Thus, a larger sample size may be needed to determine if the variation in the relationship between desire and motivation are significant.

Limitations

This study had several important limitations. First, the study sample was a small, convenience sample recruited online with low response and completion rates. The mothers that volunteered to participate in the study and those that completed it, may be different in unknown ways from the general population of new mothers. For example, mothers that were more comfortable with their sexuality or who had noticed greater changes in sexuality may have been more likely to participate and complete the study. Likewise, sampling from online mother groups may have overly sampled mothers with lower partner and social support, as they may be more likely to be in support/social groups. This small size made the sample less likely to be representative of the population and made it difficult to discern if specific individuals in the sample were driving detected effects or masking others. Additionally, the overall size of the sample provided low power, making it difficult to detect small, but significant effects. As maternal sexuality is depressed during lactation and early motherhood, changes may be slight. A larger sample size would diversify the sample and enable detection of variation in maternal sexuality at a time when it is depressed overall.

Second, the study design had limited control. While participants were randomly assigned to session instructions (20 minutes after breastfeeding vs. 120 minutes and morning vs evening), they participated at a wide variety of times. Likewise, there was no way to verify that instructions were read carefully and followed correctly. Mothers may have interpreted and stated the timing differently. For example, mothers might have participated 20 minutes after *starting* to breastfeed her infant or 20 minutes after *finishing* breastfeeding. These may have been reported differently in the time since last breastfeeding too. Twenty minutes after starting the breastfeeding session could have been noted as 5 minutes (since the session ended 5 minutes previous) or 25 minutes (as it started 20 minutes previous). Time since breastfed (20 vs 120 minutes) did correlate significantly with minute (reported minutes since breastfeeding), however the correlation strength should have been higher. Please see Figures 1 and 2 for histograms detailing the reported minutes since breastfeeding for those participating 20 minutes after breastfeeding and those participating 120 minutes after breastfeeding. Further study of this topic could address timing with more specific instructions but would be better served by obtaining the measures in a lab space. It would also be beneficial to obtain hormone measures. Oxytocin is related to bonding (Numan & Young, 2016) and may play a role in partner-connection related sexual motivations during breastfeeding.

Third, the timing may be of particular importance if the time elapsed since breastfeeding does not linearly predict sexuality. For example, the effect of breastfeeding recency on in-pair sexual desire showed up when participants were grouped into 20 and 120 minutes after breastfeeding, but not when minutes from breastfeeding was measured continuously. This may mean that the effect is curvilinear and may have level periods and rapid changes. If hormones are involved in lactational maternal sexuality, this may very well be the case, as breastfeeding stimulates the release of prolactin and oxytocin and then they decrease over time (McNeilly et al., 1983). Future studies may benefit from the addition of multiple time samples.

Fourth, the study relied on self-report for the dependent variables. Participants were relied on to accurately and honestly share their current level of sexual desire and sexual motivations. Sharing information about pair-bond quality, sexual desire, and motivation may be vulnerable to response bias. Mothers may also vary in their interpretation of questions. For example, questions about partner attractiveness may be responded to objectively, how attractive the partner *is* in relation to others or may be interpreted more subjectively to address how attractive the mother *finds* their partner in relations to others.

Lastly, it is possible that many of these mothers may not face the same energy constraints that ancestral females would have. Thus, mothers in this study be able to afford simultaneous investment into breastmilk and their pair-bond. The average BMI for mothers in this study was 27.56. Though current BMI is undoubtedly influenced by weight gain during pregnancy, 27.56 would fit into the overweight categorization for BMI. Future research in this area should address the energetic tradeoffs in populations with limited resources, for whom resource allocation may have greater importance.

Conclusions

In general, partial support for the hypotheses were found. Breastfeeding recency did impact in-pair desire, though it was not associated with extra-pair desire or sexual motivation. Accordingly, it may be possible for infants to influence maternal trade-offs between parenting and mating effort by temporarily suppressing in-pair sexual desire. As in-pair sexual desire predicted the frequency of sexual activity and both measured sexual motivations, this suppression would reduce sexual activity and thus help lengthen the interbirth interval.

Likewise, relationship quality predicted connection-related sexual motivation and may interact with breastfeeding recency and infant age to predict pleasure-related sexual motivation. Mothers in better quality relationships reported higher partner-connection sexual motivations, indicating that they may split energy allocation between parenting effort and relationship maintenance in order to preserve their pair-bond during the postnatal period. Mothers in lower quality relationships showed higher extra-pair sexual desire. Thus, it is possible that some of these mothers are allocating some energy toward mating effort, though not toward their current partner.

This study provided preliminary knowledge about how breastfeeding and relationship quality may impact maternal sexuality during lactation. However, most effects in this study were marginal and significant predictors of intraindividual variation were not found. Larger studies with higher power are needed to investigate them. Research on how hormonal and energetic changes correspond to maternal sexuality is also needed. Understanding more about fluctuations in sexuality within an individual and the potential for infant breastfeeding behavior to influence maternal sexuality remain a missing piece in the puzzle of female sexuality during lactation.

References

Abebe, G.M., & Yohannis, A. (1996). Birth interval and pregnancy outcome. *East African Medical Journal, 73*(8), 552-555.

Adinma, J.I. (1995). Sexuality in Nigerian pregnant women: perceptions and practice. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 35*(3), 290-293.

Adinma, J.I. (1996). Sexual activity during and after pregnancy. *Advances in Contraception*, *12*(1), 53-61.

Ahlborg, T., Dahlof, L.G., & Hallberg, L.R. (2005). Quality of intimate and sexual relationship in first-time parents six months after delivery. *The Journal of Sex Research*, *42*(2), 167-174.

Alder, E.M. (1989). Sexual behaviour in pregnancy, after childbirth and during breast-feeding. *Bailliere's Clinical Obstetrics and Gynaecology, 3*(4), 805-821.

Alder, E., & Bancroft, J. (1988). The relationship between breast feeding persistence, sexuality and mood in postpartum women. *Psychological Medicine, 18*(2), 389-396.

Alder, E.M., Cook, A., Davidson, D., West, C., & Bancroft, J. (1986). Hormones, mood and sexuality in lactating women. *The British Journal of Psychiatry, 148*, 74-79.

Allen-Blevins, C.R., Sela, D.A., Hinde, K. (2015). Milk bioactives may manipulate microbes to mediate parent-offspring conflict. *Evolution, Medicine, and Public Health*, *2015*(1), 106-121.

Alsaweed, M., Hartmann, P.E., Geddes, D.T., & Kakulas, F. (2015). MicroRNAs in breastmilk and the lactating breast: Potential immunoprotectors and developmental regulators for the infant and the mother. *International Journal of Environmental Research and Public Health, 12*(11), 13981-14020.

Alsaweed, M., Lai, C.T., Hartmann, P.E., Geddes, D.T., & Kakulas, F. (2016). Human milk cells contain numerous miRNAs that may change with milk removal and regulate multiple physiological processes. *International Journal of Molecular Sciences, 17*(6), doi: 10.3390/ijms17060956.

American Academy of Pediatrics. (2012). Breastfeeding and use of human milk. *Pediatrics, 129*(3), e827-e841.

Arslan, R.C., Schilling, K.M., Gerlach, T.M., & Penke, L. (2018). Using 26,000 diary entries to show ovulatory changes in sexual desire and behavior. *Journal of Personality and Social Psychology*, doi: 10.1037/pspp0000208

Aryal, T.R. (2010). Determinants of post-partum amenorrhea among Nepalese rural mothers: a multivariate analysis. *Kathmandu University Medical Journal, 8*(29), 5-11.

Avery, M. D., Duckett, L., & Frantzich, C.R. (2000). The experience of sexuality during breastfeeding among primiparous women. *Journal of Midwifery and Women's Health, 45*(3), 227-237.

Ayrim, A., Gunduz, S., Akcal, B., & Kafali, H. (2014). Breastfeeding throughout pregnancy in Turkish women. *Breastfeeding Medicine, 9*(3), 157-160.

Bardanzellu, F., Fanos, V., Strigini, F.A.L., Artini, P.G., & Peroni, D.G. (2018). Human breast milk: Exploring the linking ring among emerging components. *Frontiers in Pediatrics, 6*(215), doi: 10.3389/fped.2018.00215.

Barclay, L.M., McDonald, P., & O'Loughlin, J.A. (1994). Sexuality and pregnancy. An interview study. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 34*(1), 1-7.

Barrett, E.S., Parlett, L.E., Windham, G.C., & Swan, S.H. (2014). Differences in ovarian hormones in relation to parity and time since last birth. *Fertility and Sterility, 101*(6), 1773-1780.

Barret, G., Pendry, E., Peacock, J., Victor, C., Thakar, R., Manyonda, I. (1999). Women's sexuality after childbirth: a pilot study. *Archives of Sexual Behavior, 28*(2), 179-191.

Barret, G., Pendry, E., Peacock, J., Victor, C., Thakar, R., Manyonda, I. (2000). Women's sexual health after childbirth. BJOG, 107(2), 186-195.

Bass, J. & Takashi, J.S. (2010). Circadian integration of metabolism and energetics. *Science, 330*(6009), 1349-1354.

Berhanu, B., & Hogan, D. (1998). Postpartum amenorrhoea in Ethiopia: the role of weaning, child death, and socioeconomic factors. *Social Biology, 45*(1-2), 80-95.

Blurton Jones, N. (1986). Bushman birth spacing: A test for optimal interbirth intervals. *Evolution and Human Behavior, 7*(2), 91-105.

Blurton Jones, N.G., & da Costa, E. (1987). A suggested adaptive value of toddler night waking: Delaying the birth of the next sibling. *Evolution and Human Behavior, 8*(2), 135-142.

Boddy, A.M., Fortunato, A., Wilson Sayres, M., & Aktipis, A. (2015). Fetal microchimerism and maternal health: a review and evolutionary analysis of cooperation and conflict beyond the womb. Bioessays, 37(10), 1106-1118.

Bogin, B., Silva, M.I., & Rios, L. (2007). Life history trade-offs in human growth: Adaptation or pathology? *American Journal of Human Biology, 19*(5), 631-642.

Bohler, E., & Bergstrom, S. (1995). Premature weaning in east Bhutan: Only if mother is pregnant again. *Journal of Biosocial Science, 27*(3), 253-265.

Bohler, E., & Bergstrom, S. (1996). Child growth during weaning depends on whether mother is pregnant again. *Journal of Tropical Pediatrics, 42*(2), 104-109.

Brezsnyak, M., & Whisman, M.A. (2004). Sexual desire and relationship functioning: The effects of marital satisfaction and power. *Journal of Sex and Marital Therapy, 30*(3), 199-217.

Brown, A., Rance, J., & Warren, L. (2015). Body image concerns during pregnancy are associated with a shorter breastfeeding duration. *Midwifery, 31*(1), 80-89.

Brunner Huber, LR., Smith, K.S., Sha, W., & Vick, T. (2018). Interbirth interval and pregnancy complications and outcomes: Findings from the pregnancy risk assessment monitoring system. *Journal of Midwifery and Women's Health, 63*(4), doi: 10.1111/jmwh.12745.

Burrows, L.J., Basha, M., & Goldstein, A.T. (2012). The effects of hormonal contraceptives on female sexuality: A review. *The Journal of Sexual Medicine, 9*(9), 2213-2223.

Butte, N.F., & King, J.C. (2005). Energy requirements during pregnancy and lactation. *Public Health Nutrition, 8*(7A), 1010-1027.

Butte, N.F., Lopez-Alarcon, M.G., Garza, C. (2002). Nutrient adequacy of exclusive breastfeeding for the term infant during the first six months of life. Geneva: World Health Organization, http://www.who.int/iris/handle/10665/42519.

Byrd, J.E., Hyde, J.S., DeLamater, J.D., & Plant, E.A. (1998). Sexuality during pregnancy and the year postpartum. *The Journal of Family Practice, 47*(4), 305-308.

Call, V., Sprecher, S., & Schwartz, P. (1995). The incidence and frequency of marital sex in a national sample. *Journal of Marriage and the Family, 57*(3), 639-652.

Carlson, M.J., Pilkauskas, N.V., McLanahan, S.S., Brooks-Gunn, J. (2011). Couples as partners and parents over children's early years. *Journal of Marriage and Family, 73*(2), 317-334.

Casto, K.V., & Edwards, D.A. (2016). Testosterone, cortisol, and human competition. *Hormones and Behavior, 82*, 21-37.

Committee on Obstetric Practice (2018). Optimizing postpartum care. American College of Obstetricians and Gynecologists Committee Opinion, Number 736. https://www.acog.org/Clinical-Guidance-and-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Optimizing-Postpartum-Care

Condon, J.T., & Boyce, P., & Corkindale, C.J. (2004). The First-Time Fathers Study: a prospective study of the mental health and wellbeing of men during the transition to parenthood. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, *38*(1-2), 56-64.

Cox, M.J., Owen, M.T., Lewis, J.M., & Henderson, V.K. (1989). Marriage, adult adjustment, and early parenting. *Child Development*, *60*(5), 1015-1024.

Da Vanzo, J., Hale, L., Razzaque, A., & Rahman, M. (2008). The effects of pregnancy spacing on infant and child mortality in Matlab, Bangladesh: How they vary by the type of pregnancy outcome that began the interval. *Population Studies, 62*(2), 131-154.

Dada, O.A., Adesode, F.A., Olanrewaju, D.M., Olowu, O.A., Sule-Odue, O., Fakoya, T.A., Oluwole, F.A. & Odunlami, B.V. (2002). Infant feeding and lactational amenorrhea in Sagamu, Nigeria. *African Journal of Reproductive Health, 6*(2), 39-50.

Dada, O.A., & Laditan, A.A. (1982). Circulating hormonal levels during prolonged lactational amenorrhea. *International Journal of Clinical Chemistry, 123*(3), 187-192.

Daly, S.E., & Hartmann, P.E. (1995). Infant demand and milk supply. Part 1: Infant demand and milk production in lactating women. *Journal of Human Lactation, 11*(1), 21-26.

Daly, S.E., & Hartmann, P.E. (1995). Infant demand and milk supply. Part 2: The short-term control of milk synthesis in lactating women. *Journal of Human Lactation, 11*(1), 27-37 .

De Jonge, H.C., Azad, K., Seward, N., Kuddus, A., Shaha, S., Beard, J., Costello, A., Houwelling, T.A., & Fottrell, E. (2014) Determinants and consequences of short birth interval in rural Bangladesh: A cross-sectional study. *BMC Pregnancy and Birth, 14*, doi: 10.1186/s12884-014-0427-6.

De Judicibus, M.A., & McCabe, M.P. (2002). Psychological factors and the sexuality of pregnant and postpartum women. *The Journal of Sex Research, 39*(2), 94-103.

Diaz, S., & Croxatto, H.B. (1993). Contraception in lactating women. *Current Opinion* *in Obstetrics and Gynecology, 5*(6), 815-822.

Diaz, S., Seronferre, M., Cardenas, H., Schiappacasse, V., Brandeis, A., & Croxatto, H.B. (1989). Circadian variation of basal plasma prolactin, prolactin response to suckling, and length of amenorrhea in nursing women. *Journal of Clinical Endocrinology and Metabolism, 68* (5), 946-955.

Dufour, D.L., & Sauther, M.L. (2002). Comparative and evolutionary dimensions of the energetics of human pregnancy and lactation. *American Journal of Human Biology, 14*(5), 584-602.

Ellison, P.T. (2001). *On Fertile Ground: A Natural History of Human Reproduction*. Cambridge, MA: Harvard University Press.

Ellison, P.T. (2003). Energetics and reproductive effort. *American Journal of Human Biology, 15*(3), 342-351.

Ellison, P.T. (2005). Evolutionary perspectives on the fetal origins hypothesis. *American Journal of Human Biology, 17*(1), 113-118.

Ellison, P.T. (2017). Endocrinology, energetics, and human life history: A synthetic model. *Hormones and Behavior, 91*, 97-106.

Emery Thompson, M., Muller, M.M., & Wrangham, R.W. (2013). The energetics of lactation and the return to fecundity in wild chimpanzees. *Behavioral Ecology, 23*(6), 1234-1241.

Escasa-Dorne, M.J. (2015). Sexual functioning and commitment to their current relationship among breastfeeding and regularly cycling women in Manila, Philippines. *Human Nature, 25*(1), 89-101.

Fisher, H..E. (1989). Evolution of human serial pair bonding. *American Journal of*

Physical Anthropology, 78(3), 331-354.

Fleming, A.S., Corter, C., Stallings, J., & Steiner, M. (2002). Testosterone and prolactin are associated with emotional responses to infant cries in new fathers. *Hormones and Behavior, 42*(4), 399-413.

Fletcher, G.J.O., Simpson, J.A. & Thomas, G. (2000). The measurement of perceived relationship quality components: A confirmatory factor analytic approach. *Personality and Social Psychology Bulletin, 26*(3), 340-354.

Forste, R. (1998). Infant feeding practices and child health in Bolivia. Journal of *Biosocial Science, 30*(1), 107-125.

Forster, C., Abraham, S., Taylor, A., & Llewellyn-Jones, D. (1994). Psychological and sexual changes after the cessation of breastfeeding. *Obstetrics and Gynecology, 84*(5), 872-876.

Fotso, J.C., Cleland, J., Mberu, B., Mutua, M., & Elungata, P. (2013). Birth spacing and child mortality: An analysis of prospective data from Nairobi urban health and demographic surveillance system. *Journal of Biosocial Science, 45*(6), 779-798

Fujiwara, T., Barber, C., Schaechter, J., & Hemenway, D. (2009). Characteristics of infant homicides: findings from a U.S. multisite reporting system. *Pediatrics, 124*(2), e210-217.

Geary, D.C. (20). Evolution and proximate expression of human paternal investment. *Psychological Bulletin, 126*(1), 55-77.

Georgakopoulous, P.A., Dodos, D., Mechleris, D. (1984). Sexuality in pregnancy and premature labor. *The British Journal of Obstetrics and Gynaecology, 91*(9), 891-893.

Gibson, M.A., & Mace, R. (2006). An energy-saving development initiative increases birth rate and childhood malnutrition in rural Ethiopia. *PLoS Medicine, 3*(4), e87.

Glasier, A., McNeilly, A.S., & Howie, P.W. (1984). The prolactin response to suckling. *Clinical Endocrinology, 21*(2), 109-116.

Goldsmith, F., O'Sullivan, A., Smilowitz, J.T., & Freeman, S.L. (2015). Lactation and intestinal microbiota: How early diet shapes the infant gut. *Journal of Mammary Gland Biology and Neoplasia, 20*(3-4), 149-158.

Gray, P. B., & Anderson, K. G. (2010). *Fatherhood: Evolution and Human Paternal Behavior*. Cambridge, MA: Harvard University Press.

Grebe, N.M., Emery Thompson, M., & Gangestad, S.W. (2016). Hormonal predictors of women's extra-pair vs. in-pair sexual attraction in natural cycles: Implications for extended sexuality. *Hormones and Behavior, 78*, 211-219.

Gross, B.A., & Burger, H. (2002). Breastfeeding patterns and return to fertility in Australian women. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 4*(2), 148-154.

Haig, D. (1993). Genetic conflicts in human pregnancy. The Quarterly Review of Biology, 68(4), 495-532.

Haig, D. (2014a). Interbirth intervals: Intrafamilial, intragenomic, and intrasomatic conflict. *Evolution, Medicine, and Public Health, 1*, 12-17.

Haig, D. (2014b). Troubled sleep: Night waking, breastfeeding and parent-offspring conflict. *Evolution, Medicine, and Public Health, 2014*(1), 32-39.

Hauff, L.E., & Demerath, E.W. (2012). Body image concerns and reduced breastfeeding duration in primiparous overweight and obese women. *American Journal of Human Biology, 24*(3), 339-349.

Hays R.D., & Stewart AL. (1992). Sleep measures. In: Stewart AL, Ware JE Jr, Eds. *Measuring Functioning and Well-being: The Medical Outcomes Study Approach*. (pp 235). Durham, NC: Duke University Press.

Heinrichs, M., Meinlschmidt, G., Neumann, I., Wanger, S., Kirschbaum, C., Ehlert, U., & Hellhammer, D.H. (2001). Effects of suckling on hypothalamic-pituitary-adrenal axis responses to psychosocial stress in postpartum lactating women. *Journal of Clinical Endocrinology and Metabolism, 86*(10), 4798-4804.

Heinrichs, M., Neumann, I., & Ehlert, U. (2002). Lactation and stress: Protective effects of breast-feeding in humans. *Stress – The International Journal on the Biology of Stress, 5*(3), 195-203.

Hill, E.M. (1988). The menstrual cycle and components of human sexual behavior. *Journal of Social and Biological, 11*(4), 443-455.

Hill, P.D., Chatterton, R.T., & Aldag, J.C. (1999). Prolactin in breastfeeding: State of the science. *Biological Research for Nursing, 1*(1), 65-75.

Hinde, K. (2014). Essential tensions in infant rearing. *Evolution, Medicine, and Public Health, 2014*(1), 48-50.

Hinde, K., Skiebel, A.L., Foster, A.B., Del Rosso, L., Mendoza, S.P., & Capitanio, J.P. (2015). Cortisol in mother's milk across lactation reflects maternal life history and predicts infant temperament. *Behavioral Ecology, 26*(1), 269-281.

Hipp, L.E., Kane Low, L., van Anders, S.M. (2012). Exploring women's postpartum sexuality: social, psychological, relational, and birth-related contextual factors. *The Journal of Sex Medicine, 9*(9), 2330-2341.

Hodson, D.J., Townsend, J., & Tortonese, D.J. (2010). Characterization of the effects of prolactin in gonadotroph target cells. *Biology of Reproduction, 83*(6), 1046-1055.

Hruschka, D.J., & Hagaman, A. (2015). The physiological cost of reproduction for rich and poor across 65 countries. *American Journal of Human Biology, 27*(5), 654-659.

Hunter, T., & Cattelona, G. (2014). Breastfeeding initiation and duration in first-time mothers: exploring the impact of father involvement in the early post-partum period. *Health Promotion Perspective*, *4(*2), 132-136.

Jasienska, G. (2009). Reproduction and lifespan: Trade-offs, overall energy budgets, intergenerational costs, and costs neglected by research. *American Journal of Human Biology, 21*(4), 524-532.

Jayachandran, S., & Kuziemko, I. (2011). Why do mothers breastfeed girls less than boys? Evidence and implications for child health in India. *The Quarterly Journal of Economics*, *126*(3), 1485-1538

Johnston, J.M. & Amico, J.A. (1986). A prospective longitudinal study of the release of oxytocin and prolactin in response to infant suckling in long term lactation. *The Journal of Clinical Endocrinology and Metabolism, 62*(4), 653-657.

Jones, R.E. (1989). The effects of weaning, infant-mortality, and breastfeeding patterns on fertility in rural Indonesia – modeling competing risks using hazard model analysis. *American Journal of Physical Anthropology*, *78*(2), 248

Joshi, U.M., Joseph, R., Adatia, A.R., Choudhary, V.N., Joshi, J.V., Mehta, S., & Hazari, K.T. (1980). Serum progesterone in women with lactation amenorrhoea. *The Indian Journal of Medical Research, 72*, 508-511.

Kenny, J.A. (1973). Sexuality of pregnant and breastfeeding women. Archives and *Sexual Behavior, 2*(3), 215-229.

Khajehei, M., Doherly, M., Tilley, P.J., & Sauer, K. (2015). Prevalence and risk factors of sexual dysfunction in postpartum Australian women. *The Journal of Sexual Medicine, 12*(6), 1415-1426.

Kim, P., Feldman, R., Mayes, L.C., Eicher, V., Thompson, N., Leckman, J.F., & Swain, J.E. (2011). Breastfeeding, brain activation to own infant cry, and maternal sensitivity. *Journal of Child Psychology and Psychiatry, 52*(8), 907-915.

Kimani, M. (2001). Behavioural effects of infant and child mortality on fertility in Kenya. *African Journal of Reproductive Health, 5*(3), 63-72.

Kirchengast, S., & Winkler, E.M. (1996). Differential fertility and body build in !Kung San and Kavango females from northern Namibia. *Journal of Biosocial Science, 28*(2), 193-210.

Kochenour, N.K. (1980). Lactation suppression. *Clinical Obstetrics and Gynecology, 23*(4), 1045-1059.

Kruger, T.H.C., Hartmann, U., & Schedlowski, M. (2005). Prolactinergic and dopaminergic mechanisms underlying sexual arousal and orgasm in humans. *World Journal of Urology, 23*(2), 130-138.

Kuate, D.B. (1997). Effects of infant feeding practices and birth spacing on infant and child survival: A reassessment from retrospective and prospective data. *Journal of Biosocial Science, 29*(3), 303-326.

Labbok, M.H., Hight-Laukaran, V., Peterson, A.E., Fletcher, V., von Hertzen, H., & Van Look, P.F.A. (1997). Multicenter study of the Lactational Amenorrhea Method (LAM): I. efficacy, duration, and implacations for clinical application. *Contraception, 55*(6), 327-336.

LaMarre, A.K., Paterson, L.Q., & Gorzalka, B.B. (2003). Breastfeeding and postpartum maternal sexual functioning: A review. *The Canadian Journal of Human Sexuality, 12*(3-4), 151-168.

Lanza, N., Valeggia, C., & Pelaez, E. (2013). The reproductive transition in an indigenous population of northern Argentina. *Biodemography and Social Biology, 59*(2), 212-230.

Larson, C.M., Pillsworth, E.G., & Haselton, M.G. (2012). Ovulatory shifts in women's attractions to primary partners and other men: further evidence of the importance of primary partner sexual attractiveness. *PLoS One, 7*(9), 1-10.

Lawrence, E., Rothman, A.D., Cobb, R.J., Rothman, M.T., & Bradbury, T.N. (2008). Marital satisfaction across the transition to parenthood. *Journal of Family Psychology, 22*(1), 41-50.

Lawson, D.W., Alvergne, A., & Gibson, M.A. (2012). The life-history trade-off between fertility and child survival. *Proceedings: Biological Sciences, 279*(1748), 4755-4764.

Leavitt, C.E., McDaniel, B.T., Mass, M.K., & Feinberg, M.E. (2017). Parenting stress and sexual satisfaction among first-time parents: A dyadic approach. *Sex Roles, 76*(5-6), 346-355.

Lemay, D.G., Neville, M.C., Rudolph, M.C., Pollard, K.S., & German, B. (2007). Gene regulatory networks in lactation: Identification of global principles using bioinformatics. *BME Systems Biology, 1*(56), https://doi.org/10.1186/1752-0509-1-56

Li, R., Fein, S.B., & Grummer-Strawn, L.M. (2010). Do infants fed from bottles lack self-regulation of milk intake compared with directly breastfed infants? *Pediatrics, 125*(6), e1386-e1393

Lumley, J. (1978). Sexual feelings in pregnancy and after childbirth, *Obstetrics and Gynaecology*, *18*(2), 114-117.

Lunn, P.G., Austin, S., Prentice, A.M., & Whitehead, R.G. (1984). The effect of improved nutrition on plasma prolactin concentrations and postpartum infertility in lactating Gambian women. *American Journal of Clinical Nutrition, 39*(2), 227-235.

Malakoti, J., Zamanzadeh, V., Maleki, A., & Farshbaf-Khalili, A. (2012). Sexual function in breastfeeding women in family health centers of Tabriz, Iran. *Journal of Caring Sciences, 2(*2), 141-146.

Marlowe, F.W. (2003). A critical period for provisioning by Hadza men: Implications for pair bonding. *Evolution and Human Behavior, 24*, 217- 229.

Marquis, G.S., Penny, M.E., Diaz, J.M., Marin, R.M. (2002). Postpartum consequences of an overlap of breastfeeding and pregnancy: reduced breast milk intake and growth during early infancy. *Pediatrics, 109*(4), e56.

Marquis, G.S., Penny, M.E., Zimmer, J.P., Diaz, J.M., & Marin, R.M. (2003). An overlap of breastfeeding during late pregnancy is associated with subsequent changes in colostrum composition and morbidity rates among Peruvian infants and their mothers. *The Journal of Nutrition*, *133*(8), 2585-2591.

Martin, M.A., Garcia, G., Kaplan, H.S., Gurven, M.D. (2016). Conflict or congruence? Maternal and infant-centric factors associated with shorter exclusive breastfeeding durations among the Tsimane. *Social Science and Medicine, 170*, 9-17.

Mattison, S.M., Wander, K., and Hinde, K. (2015). Breastfeeding over two years is associated with longer birth intervals, but not measures of growth or health, among children in Kilimanjaro, TZ. *American Journal of Human Biology, 27*(6), 807-815.

McCall, K., & Meston, C. (2006). Cues resulting in desire for sexual activity in women. *The Journal of Sex Medicine, 3*(5), 838-852.

McDade, T.W., Metzger, M.W., Chyu, L., Duncan, G.J., Garfield, C., & Adam, E.K. (2014). Long-term effects of birth weight and breastfeeding duration on inflammation in early adulthood. *Proceedings of the Royal Society B: Biological Sciences, 281*(1784), doi: 10.1098/rspb.2013.3116.

McGuire, E., (2013). Maternal and infant sleep postpartum. *Breastfeeding Review, 21*(2), 38-41.

McNeilly, A.S., Robinson, I.C., Houston, M.J., & Howie, P.W. (1983). Release of oxytocin and prolactin in response to suckling, *British Medical Journal (Clinical Research Ed.), 286*(6361), 257-259.

McNulty, J.K., Wenner, C.A., & Fisher, T.D. (2016). Longitudinal associations among relationship satisfaction, sexual satisfaction, and frequency of sex in early marriage. *Archives of Sexual Behavior, 45*(1), 85-97.

Meehan, C.L., Lackey, K.A., Hagen, E.H., Williams, J.E., Roulette, J., Helfrecht, C. McGuire, M.A., & McGruire, M.K. (2018). Social networks, cooperative breeding, and the human microbiome. *American Journal of Human Biology, 30*(4), e23131. doi: 10.1002/ajhb.23131

Melchior, L.A., Huba, G.J., Brown, V.B., Reback, C.J. (1993). A short depression index for women. *Educational and Psychological Measurement, 53*, 1117–1125.

Merchant, K., Martorell, R., & Haas, J. (1990a). Maternal and fetal responses to the stresses of lactation concurrent with pregnancy and short recuperative intervals. *American Journal of Clinical Nutrition, 52*(2), 280-288.

Merchant, K., Martorell, R., & Haas, J. (1990b). Consequences for maternal nutrition of reproductive stress across consecutive pregnancies. *American Journal of Clinical Nutrition, 52*(4), 616-620.

Meston, C. M., & Buss, D. M. (2007). Why humans have sex. *Archives of Sexual Behavior, 36*(4), 477–507.

Moran, C., Alcazar, L.S., Carranza-Lira, S., Merino, G., & Bailon, R. (1994). Recovery of ovarian function after childbirth, lactation and sexual activity with relation to age of women. *Contraception, 50*(5), 401-407.

Moscone, S.R., & Moore, M.J. (1993). Breastfeeding during pregnancy. Journal of *Human Lactation, 9*(2), 83-88.

Naidoo, S. (2000). A profile of the oro-facial injuries in child physical abuse at a children's hospital. *Child Abuse and Neglect, 24*(4), 521-534.

Nedeltcheva, A.V., & Scheer, F.A. (2014). Metabolic effects of sleep disruption, links to obesity and diabetes. *Current Opinion in Endocrinology, Diabetes, and Obesity, 21*(4), 293-298.

Numan, M., & Young, L.J. (2016). Neural mechanisms of mother-infant bonding and pair ponding: Similarities, differences, and broader implications. *Hormones and Behavior, 77*, 98-112.

Olsson, A., Robertson, E., Bjorklund, A., Nissen, E. (2010). Fatherhood in focus, sexual activity can wait: new fathers' experience about sexual life after childbirth. *Scandinavian Journal of Caring Sciences, 24*(4), 716-725.

Peng, Y.K., Hight-Laukaran, V., Peterson, A.E., & Perez-Escamilla, R. (1998). Maternal nutritional status is inversely associated with lactational amenorrhea in Sub-Saharan Africa: Results from demographic and health surveys II and III. *The Journal of Nutrition, 128*(10), 1672-1680.

Pillsworth, E.G., Haselton, M.G., & Buss, D.M. (2004). Ovulatory shifts in female sexual desire. *The Journal of Sex Research, 41*(1), 55-65.

Prentice, A.M., & Prentice, A. (1995). Evolutionary and environmental influences on human lactation. *Proceedings of the Nutrition Society, 54*(2), 391-400.

Pillsworth, E.G., Haselton, M.G., & Buss, D.M. (2004). Ovulatory shifts in female sexual desire. *The Journal of Sex Research, 41*(1), 55-65.

Prentice, A.M., & Prentice, A. (1988). Energy costs of lactation. *Annual Review of Nutrition, 8*, 63-79.

Prieto, C.R., Cardenas, H., & Croxatto, H.B. (1999). Variability of breast sucking, associated milk transfer and the duration of lactation amenorrhoea. *Journal of*

Reproduction and Fertility, 115(2), 193-200.

Prosser, C.G., Saint, L., & Hartman, P.E. (1984). Mammary gland function during gradual weaning and early gestation in women. *The Australian Journal of Experimental Biology and Medical Science, 62*, 215-228.

Quinlan, R.J., & Quinlan, M.B. (2008). Human lactation, pair-bonds, and alloparents: A cross-cultural analysis. *Human Nature*, *19*(1), 87-102.

Radloff, L.S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*(3), 385–401.

Raisanen, J.C., Chadwick, S.B., Michalak, N., & van Anders, S.M. (2018). Average associations between sexual desire, testosterone, and stress in women and men over time. *Archives of Sexual Behavior, 47*(6), 1613-1631.

Reamy, K., & White, S.E. (1987). Sexuality in the puerperium: A review. *Archives of Sexual Behavior, 16*(2), 165-186.

Regan, P.C. (1996). Rhythms of desire: The association between menstrual cycle phases and female sexual desire. *The Canadian Journal of Human Sexuality, 5*(3), 145-156.

Rezaei, N., Azadi, A., Savehmiri, K., & Valizadeh, R. (2017). Postpartum Sexual Functioning and Its Predicting Factors among Iranian Women. *Malaysian Journal of Medical Sciences, 24*(1), 94-103.

Riskin, A., Almog, M., Peri, R., Halasz, K., Srugo, I., & Kessel, A. (2012). Changes in immunomodulatory constituents of human milk in response to active infection in the nursing infant. *Pediatric Research, 71*(2), 220-225.

Romito, P. (1988). Mothers' experience of breastfeeding. *Journal of Reproductive and*

Infant Psychology, 6(2), 89-99.

Roney, J.R., Mahler, S.V., & Maestripieri, D. (2003). Behavioral and hormonal responses of men to brief interactions with women. *Evolution and Human Behavior*, *24*, 365-375.

Roney, J.R., & Simmons, Z.L. (2016). Within-cycle fluctuations in progesterone negatively predict changes in both in-pair and extra-pair desire among partnered women. *Hormones and Behavior, 81*, 45-52.

Rosen, R., Brown, C., Heiman, J., Leiblum, S., Meston, C., Shabsigh, R., Ferguson, D., & D'Agostino, R. Jr. (2000). The female sexual function index (FSFI): A multidimensional self-report instrument for the assessment of female sexual function. *Journal of Sex & Marital Therapy*, *26*(2), 191-208.

Rosetta, L., & Madcie-Taylor, C.G. (2009). Factors in the regulation of fertility in deprived populations. *Annals of Human Biology, 36*(5), 642-652.

Rowland, M., Foxcroft, L., Hopman, W.M., & Patel, R. (2005). Breastfeeding and sexuality immediately post partum. *Canadian Family Physician*, *51*, 1366-1367.

Rutstein, S.O. (2005). Effects of preceding birth intervals on neonatal, infant and under-5 years mortality and nutritional status in developing countries: evidence from demographic health surveys. *International Journal of Gynaecology and Obstetrics, 89* (Supp 1), S7-S24.

Schlagintweit, H.E., Bailey, K., & Rosen, N.O. (2016). A new baby in the bedroom: Frequency and severity of postpartum sexual concerns and their association with relationship satisfaction in new parent couples. *The Journal of Sexual Medicine, 13*(10), 1455-1465

Schroder, J. & Schmiedeberg, C. (2015). Effects of relationship duration, cohabitation, and marriage on the frequency of intercourse in couples: Findings from German panel data. *Social Science Research, 52*, 72-82.

Sellen, D.W. (2001). Comparison of infant feeding patterns reported for nonindustrial populations with current recommendations. *The Journal of Nutrition, 131*(10), 2707-2715.

Short, R.V. (1993) Lactation infertility in family-planning. *Annals of Medicine, 25*(2), 175-180.

Signorello, L.B., Harlow, B.L., Chekos, A.K. Repke, J.T. (2001). Postpartum sexual functioning and its relationship to perineal trauma: a retrospective cohort study of primiparous women. *American Journal of Obstetrics and Gynecology, 184*(5), 881-888.

Spiegel, K., LeProult, R., & Van Cauter, E. (1999), Impact of sleep debt on metabolic and endocrine function. *The Lancet, 354*(9188), 1435-1439

Stallings, J.F., Worthman, C.M., Panter-Brick, C., & Coates, R.J. (1996). Prolactin response to suckling and maintenance of postpartum amenorrhea among intensively breastfeeding Nepali women. *Endocrine Research, 22*(1), 1-28.

Stieglitz, J., Beheim, B.A., Trumble, B.C., Madimenos, F.C., Kaplan, H., & Gurven, M. (2015). Low mineral density of weight-bearing bone among adult women in high fertility population. *American Journal of Physical Anthropology, 156*, 637-648.

Strathearn, L., Iyengar, U., Fonagy, P., & Kim, S. (2012). Maternal oxytocin response during mother-infant interaction: associations with adult temperament. *Hormones and Behavior, 61*(3), 429-435.

Tay, C.C., Glasier, A.F., & McNeilly, A.S. (1996). Twenty-four hour patterns of prolactin secretion during lactation and the relationship to suckling and the resumption of fertility in breast-feeding women. *Human Reproduction, 11*(5), 950-955.

Thomas, M.G., Shanley, D.P., Houston, A.I., McNamara, J.M., Mace, R., & Kirkwood, T.B. (2015). A dynamic framework for the study of optimal birth intervals reveals the importance of sibling competition and mortality risks. *Journal of Evolutionary Biology, 28*(4), 885-895.

Trivers, R.L. (1974) Parent-offspring conflict. *Integrative and Comparative Biology, 14*(1), 249-264.

Twenge, J.M., Campbell, K. W., Foster, C.A., (2003). Parenthood and marital satisfaction: A metanalytic review. *Journal of. Marriage and Family, 65*(3), 574-583.

Ukegbu, A.U., Ebenebe, E.U., Ukegbu, P.O., & Onveonoro, U.U. (2011). Determinants of breastfeeding pattern among nursing mothers in Anambra State, Nigeria. *East African Journal of Public Health, 8*(3), 226-231.

Undernutrition among young children in Sub-Saharan Africa. (1996). *Newsletter (Macro Systems. Institute for Resource Development. Demographic and Health Surveys), 8*(1), 3-4.

Unuane, D., Tournaye, H., Velkeniers, B., & Poppe, K. (2011) Endocrine disorders and female infertility. *Best Practice and Research Clinical Endocrinology and Metabolism, 25*(6), 861-873.

Uvnas-Moberg, K., Widstrom, A.M., Werner, S., Matthiesen, A.S., & Winberg, J.

(1990). Oxytocin and prolactin levels in breast-feeding women. Correlation with milk yield and duration of breast-feeding. *Acta Obsetrica Gynecologica Scandinavica*, *69*(4), 301-306.

Valeggia, C., & Ellison, P.T. (2003). Impact of breastfeeding on anthropometric changes in peri-urban Toba women (Argentina). *American Journal of Human Biology, 15*(5), 717-724.

Valeggia, C., & Ellison, P.T. (2004). Lactational amenorrhoea in well-nourished Toba women of Formosa, Argentina. *Journal of Biosocial Science, 36*(5), 573-595.

Valeggia, C., & Ellison, P.T. (2009). Interactions between metabolic and reproductive functions in the resumption of postpartum fecundity. *American Journal of Human Biology, 21*(4), 559-566.

Van den Broeck, J., Eeckels, R., & Massa, G. (1996). Maternal determinants of child survival in a rural African community. *International Journal of Epidemiology, 25*(5), 998-1004.

Veening, J.G., de Jong, T.R., Waldinger, M.D., Korte, S.M., & Olivier, B. (2015). The role of oxytocin in male and female reproductive behavior. *European Journal of Pharmacology*, *753*, 209-228.

Visness, C.M., & Kennedy, K.I. (1997) The frequency of coitus during breastfeeding. *Birth, 24*(4), 253-257.

Vitzthum, V.J. (2009). The ecology and evolutionary endocrinology of reproduction in the human female. *American Journal of. Physical Anthropology, 140* (Suppl), 95-136.

Vitzthum, V.J., Spielvogel, H., Caceres, E., & Gaines, J. (2000). Menstrual patterns and fecundity among non-lactating and lactating cycling women in rural highland Bolivia: implications for contraceptive choice. *Contraception, 62*(4), 181-187.

Von Sydow, K. (1999). Sexuality during pregnancy and after childbirth: a metacontent analysis of 59 studies. *Journal of Psychosomatic Research, 47*(1), 27-49.

Von Sydow, K., Ullmeyer, M., & Happ, N. (2001). Sexual activity during pregnancy and after childbirth: results from the Sexual Preferences Questionnaire. *Journal of Psychosomatic Obstetrics and Gynecology, 22*(1), 29-40.

Wallwiener, S., Muller, Doster, A., Kuon, R.J., Plewniok, K., Feller, S., Wallwiener, M., Reck, C., Mathies, L.M., Wallwiener, C. (2017). Sexual activity and sexual dysfunction of women in the perinatal period: a longitudinal study. *Archives of Gynecology and Obstetrics, 295*(4), 873-883.

Ware, J.E., Kosinski, M., Keller, & Keller, S.D. (1994). *Sf-36 Physical and Mental Health Summary Scales: A User's Manual*. Boston, MA: The Health Institute.

Wasalathanthri, S., & Tennekoon, K.H. (2001). Lactational amenorrhea/anovulation and some of their determinants: A comparison of well-nourished and undernourished women. *Fertility and Sterility, 76*(2), 317-325.

Weaver, J.M., Schofield, T.J. & Papp, L.M. (2018) Breastfeeding duration predicts greater maternal sensitivity over the next decade. *Developmental Psychology, 54*(2), 220-227

Wells. J.C. (2003) Parent-offspring conflict theory, signaling of need, and weight gain in early life. *The Quarterly Review of Biology, 78*,169–202.

Wiley, A.S. (1998). The ecology of low natural fertility in Ladakh. *Journal of Biosocial Science, 30*(4), 457-480.

Woolhouse, H., McDonald, E., & Brown, S. (2012). Women's experiences of sex and intimacy after childbirth: making the adjustment to motherhood. *Journal of Psychosomatic Obstetrics and Gynecology, 33*(4), 185-190.

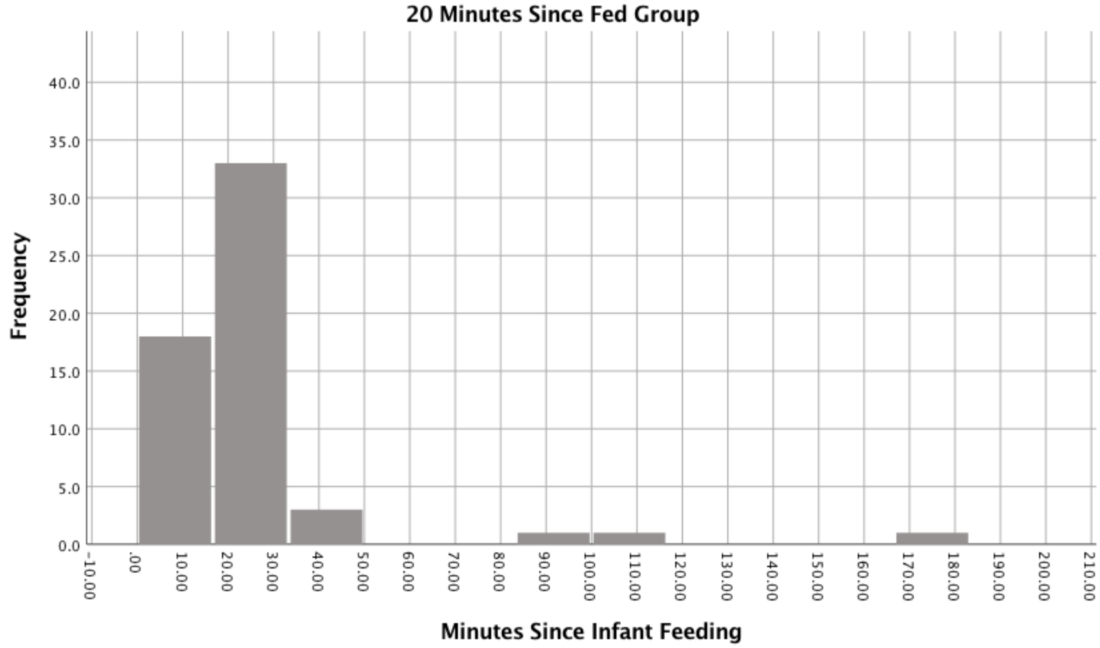
World Health Organization (2011). Exclusive breastfeeding for six months best for babieseverywhere. www.who.int/mediacentre/news/statements/2011/breastfeeding_20110115/en/

Worthman, C.M., & Kuzara, J. (2005). Life history and the early origins of health differentials. *American Journal of Human Biology, 17*(1), 95-112.

Yee., L.M., Kaimal, A.J., Nakagawa, S., Houston, K., & Kuppermann, M. (2013). Predictors of postpartum sexual activity and function in a diverse population of women. *Journal of Midwifery and Women's Health, 58*(6), 654-661.

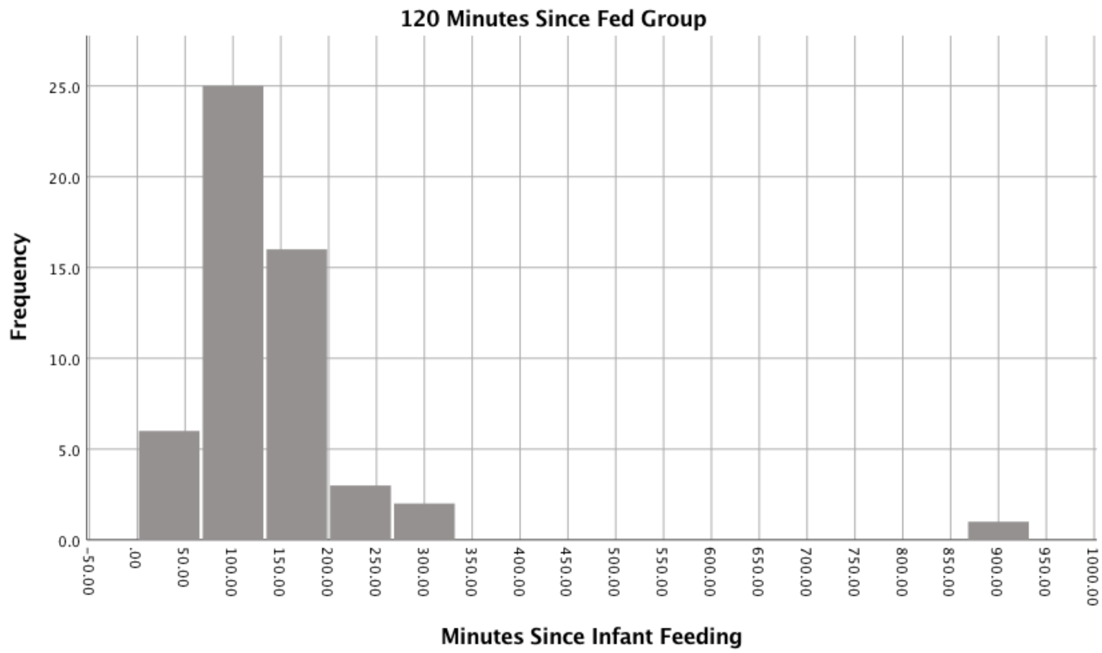
Zohoori, N., & Popkin, B.M. (1996). Longitudinal analyses of the effects of infant feeding practices on postpartum amenorrhea. *Demography, 33*(2), 167-180.

Figure 1. This figure illustrates the frequency of minutes mothers reported since last feeding their infant for participants instructed to complete the session around 20 minutes after feeding their infant. Participants also confirming that they had recently finished feeding their infant.



Notes. N=37. M= 26.05, SD= 26.83.

Figure 2. This figure illustrates the frequency of minutes mothers reported since last feeding their infant for participants instructed to complete the session around 120 minutes after feeding their infant. Participants also confirmed that it had been two hours or more since they had last fed their infant.



Notes. N=53. M=152.00, SD=117.1234.

Table 1. Loading summary for principal component analysis composite scores of sexual desire

	Extra-Pair Sexual Desire Component. Pattern Matrix Loading	In-Pair Sexual Desire Component Pattern Matrix Loading
I will feel strong attraction toward someone other than a current partner	0.740	----
I will feel sexually aroused by the sight of a very physically attractive person (not my current partner)	0.774	----
I will feed sexually aroused by the scent of a person (not my current partner)	0.760	----
I will feel strong sexual attraction toward a primary current partner	----	0.933
I will fantasize about sex with a stranger or acquaintance	0.736	----
I will fantasize about sex with a current partner	----	0.896
Rotated Sum of Squares Loadings	2.369	1.817

Notes. Loadings under 0.400 were suppressed

Table 2. Loading summary for principal component analysis composite scores of sexual motivation.

	Partner-Connection Component Pattern Matrix Loading	**Pleasure-related Component Pattern Matrix Loading**
I wanted to express my love for the person	0.929	----
I wanted to feel connected to the person	0.937	----
I wanted the pure pleasure	----	0.751
I was attracted to the person	0.892	----
The person made me feel sexy	0.776	----
It feels good	----	0.777
It's fun	----	0.699
Duty	----	0.850
Stray	----	0.837
Rotated Sum of Squares Loadings	4.453	4.195

Notes. Loadings under 0.400 were suppressed

Table 3. Initial and trimmed model results of the generalized linear mixed model regression analyses on extra-pair sexual desire and in-pair sexual desire following breastfeeding. Current relationship quality, time since breastfed, infant age, fatigue, and time of day are predictors.

Time as predictor	**In-pair Sexual Desire (n=76) df= (1, 66)**				**Extra-pair Sexual Desire (n=76) (df=1, 66)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	.568	.454	-.040	.835	1.26	.265	-.278	.227
Time Since Breastfed	4.07	.048	-.331	.048	.815	.370	-.184	.370
Infant Age	2.012	.161	-.286	.171	7.56	.008	-.305	.119
Relationship x Time	1.79	.185	.322	.185	.295	.589	.172	.589
Time x Age	.065	.800	.044	.800	.700	.406	-.208	.406
Relationship x Age	.080	.778	.192	.419	1.46	.232	.400	.281
Relationship x Time x Age	2.91	.093	-.480	.093	.159	.691	-.181	.691
Fatigue	2.46	.122	-.105	.122	.847	.361	-.040	.361
Time of Day	.105	.747	.051	.747	.237	.628	.113	.628
Trimmed	**In-pair Sexual Desire df=(1, 68)**				**Extra-pair Sexual Desire df=(1, 70)**			
	F	P	B	p	*F*	p	B	p
Relationship Quality	.843	.362	.037	.831	6.38	.014	-.332	.014
Time Since Breastfed	3.38	.070	-.283	.070	.033	.856	.040	.856
Infant Age	4.57	.036	-.350	.062	10.9	.002	-.413	.002
Relationship x Time	1.24	.270	.208	.270	----	----	----	----
Time x Age	.003	.958	-.008	.958	----	----	----	----
Relationship x Age	.199	.657	.114	.518	4.48	.038	.286	.038
Relationship x Time x Age	2.89	.093	-.348	.093	----	----	----	----
Fatigue	----	----	----	----	.420	.519	-.034	.519
Time of Day	----	----	----	----	----	----	----	----

Additional notes. Time Since Breastfed coefficients show the change from 120 minutes to 20 minutes.

Table 4. Initial and trimmed model results of generalized linear mixed model regression analyses on extra-pair sexual desire and in-pair sexual desire following breastfeeding. Current relationship quality, minutes since breastfed, infant age, fatigue, and time of day are predictors.

Minutes as predictor	**In-pair Sexual Desire (n=76) df=(1, 66)**				**Extra-pair Sexual Desire (n=76) df=(1, 66)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	.194	.661	.063	.661	3.21	.078	-.286	.078
Minutes Since Breastfed	2.15	.147	.258	.147	.002	.961	-.012	.961
Infant Age	2.50	.119	-.299	.119	4.63	.035	-.333	.035
Relationship x Minutes	4.02	.049	-.490	.049	.016	.901	.046	.901
Minutes x Age	2.12	.150	-.267	.150	.928	.339	.311	.339
Relationship x Age	.028	.869	.026	.869	2.42	.125	.362	.125
Relationship x Minutes x Age	3.26	.076	.531	.076	.001	.982	-.013	.982
Fatigue	3.05	.085	-.112	.085	.757	.388	-.038	.388
Time of Day	.050	.824	.036	.824	.206	.651	.111	.651
Trimmed	**In-pair Sexual Desire df= (1, 67)**				**Extra-pair Sexual Desire df= (1, 70)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	.252	.617	.076	.617	7.11	.010	-.352	.010
Minutes Since Breastfed	2.12	.150	.238	.150	.953	.332	-.212	.332
Infant Age	3.70	.059	-.330	.059	9.54	.003	-.391	.003
Relationship x Minutes	2.84	.097	-.384	.097	----	----	----	----
Minutes x Age	2.83	.097	-.266	.097	1.16	.285	.193	.285
Relationship x Age	.004	.949	-.010	.949	5.39	.023	.315	.023
Relationship x Minutes x Age	2.83	.097	.441	.097	----	----	----	----
Fatigue	1.72	.194	-.102	.194	----	----	----	----
Time of Day	----	----	----	----	----	----	----	----

Additional notes. Minutes since breastfed shows the change for every minute increase.

Table 5. Initial and trimmed model results of generalized linear mixed model regression analyses on pleasure sexual motivations and partner-connection sexual motivations following breastfeeding. Current relationship quality, time since breastfed, infant age and their interactions are predictors, as well as in-pair sexual desire, fatigue, and time of day.

Time as predictor	**Pleasure (n=71) df= (1, 60)**				**Connection (n=71) df= (1, 60)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
Relationship Quality	.411	.524	.135	.331	1.89	.174	.236	.208
Time Since Breastfed	.046	.831	.025	.831	.004	.950	.009	.950
Infant Age	.080	.779	.164	.472	.287	.594	-.212	.219
Relationship x Time	.475	.493	-.097	.493	.035	.852	-.042	.852
Time x Age	2.84	.097	-.206	.097	3.24	.077	.264	.077
Relationship x Age	1.50	.225	-.053	.705	.013	.910	-.130	.550
Relationship x Time x Age	7.01	.010	.417	.010	.753	.389	.226	.389
In-Pair Desire	6.24	.015	.278	.015	5.99	.017	.384	.017
Fatigue	1.66	.202	-.100	.202	1.59	.212	.092	.212
Time of Day	.320	.574	-.065	.574	.551	.461	.089	.461

Trimmed	**Pleasure df=(1, 61)**				**Connection df= (1, 64)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
Relationship Quality	.154	.697	.122	.413	5.34	.024	.283	.024
Time Since Breastfed	.572	.452	.092	.452	.047	.829	-.030	.829
Infant Age	.141	.708	.010	.956	.658	.420	-.270	.127
Relationship x Time	.890	.349	-.134	.349	----	----	----	----
Time x Age	1.30	.259	-.145	.259	3.77	.057	.287	.057
Relationship x Age	.249	.619	-.113	.425	----	----	----	----
Relationship x Time x Age	4.40	.040	.335	.040	----	----	----	----
In-Pair Desire	6.16	.016	.249	.016	3.97	.051	.219	.051
Fatigue	.541	.465	-.065	.465	2.15	.147	.113	.147
Time of Day	----	----	----	----	----	----	----	----

Note. Time Since Breastfed and Interaction coefficients show the change from 120 minutes to 20 minutes.

Table 6. Initial and trimmed model results of generalized linear mixed model regression analyses on pleasure sexual motivations and partner-connection sexual motivations following breastfeeding. Current relationship quality, time since breastfed, infant age and their interactions are predictors, as well as fatigue and time of day.

Time as predictor	**Pleasure (n=72) df=(1, 62)**				**Connection (n=72) df=(1, 62)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
Relationship Quality	.923	.340	.154	.291	4.47	.039	.284	.114
Time Since Breastfed	.165	.686	-.048	.686	.852	.360	-.133	.360
Infant Age	.001	.979	.092	.685	1.45	.233	-.346	.057
Relationship x Time	.066	.799	-.037	.799	.459	.501	.123	.501
Time x Age	2.31	.134	-.195	.134	3.81	.055	.314	.055
Relationship x Age	1.20	.278	-.025	.865	.036	.851	-.020	.921
Relationship x Time x Age	4.25	.043	.338	.043	.010	.921	-.021	.921
Fatigue	1.92	.169	-.113	.169	1.56	.216	.099	.216
Time of Day	.130	.720	-.043	.720	1.14	.289	.149	.289

Trimmed	**Pleasure df=(1, 63)**				**Connection df=(1, 65)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
Relationship Quality	.316	.576	.122	.430	5.71	.020	.298	.020
Time Since Breastfed	.028	.868	.020	.868	.379	.540	-.084	.540
Infant Age	.420	.520	-.042	.814	1.24	.270	-.327	.063
Relationship x Time	.318	.575	-.081	.575	----	----	----	----
Time x Age	1.00	.321	-.130	.321	4.51	.038	.316	.038
Relationship x Age	.241	.625	-.082	.570	----	----	----	----
Relationship x Time x Age	2.94	.091	.275	.091	----	----	----	----
Fatigue	.794	.376	-.084	.376	1.32	.256	.092	.256
Time of Day	----	----	----	----	.819	.369	.124	.369

Note. Time Since Breastfed and Interaction coefficients show the change from 120 minutes to 20 minutes.

Table 7. Initial and trimmed model results of generalized linear mixed model regression analyses on pleasure sexual motivations and partner-connection sexual motivations following breastfeeding. Current relationship quality, minutes since breastfed, infant age and their interactions are predictors, as well as, in-pair sexual desire, fatigue, and time of day.

Minutes as predictor	**Pleasure (n=71) df= (1, 60)**				**Connection (n=71) df= (1, 60)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	.856	.359	.122	.359	2.77	.101	.237	.101
Minutes Since Breastfed	.151	.699	-.060	.699	.999	.322	.136	.322
Infant Age	.226	.636	.112	.636	.170	.681	-.076	.681
Relationship x Minutes	.075	.784	.066	.784	.549	.461	.160	.461
Minutes x Age	1.82	.182	.224	.182	3.54	.065	-.279	.065
Relationship x Age	1.27	.264	.160	.264	.059	.808	.035	.808
Relationship x Minutes x Age	3.42	.069	-.504	.069	.343	.560	-.151	.560
In-Pair Desire	6.51	.013	.282	.013	5.52	.022	.363	.022
Fatigue	1.95	.168	-.105	.168	.920	.341	.072	.341
Time of Day	.065	.800	-.027	.800	.123	.727	.037	.727

Trimmed	**Pleasure df=(1, 61)**				**Connection df= (1, 64)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	.120	.730	.048	.730	4.01	.050	.213	.050
Minutes Since Breastfed	.844	.362	-.116	.362	.742	.392	.099	.392
Infant Age	.068	.796	-.046	.796	.166	.685	-.059	.685
Relationship x Minutes	.669	.417	.144	.417	----	----	----	----
Minutes x Age	3.82	.055	.240	.055	8.49	.005	-.281	.005
Relationship x Age	.005	.943	-.009	.943	----	----	----	----
Relationship x Minutes x Age	3.61	.062	-.389	.062	----	----	----	----
In-Pair Desire	6.07	.017	.245	.017	5.50	.022	.357	.022
Fatigue	.367	.547	-.056	.547	1.09	.300	.081	.300
Time of Day	----	----	----	----	----	----	----	----

Note. Minutes since breastfed shows the change for every minute increase.

Table 8. Initial and trimmed model results of generalized linear mixed model regression analyses on pleasure sexual motivations and partner-connection sexual motivations following breastfeeding. Current relationship quality, minutes since breastfed, infant age and their interactions are predictors, as well as fatigue and time of day.

Minutes as predictor	**Pleasure (n=72) df= (1, 62)**				**Connection (n=72) df= (1, 62)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	1.38	.245	.161	.245	6.39	.014	.370	.014
Minutes Since Breastfed	.001	.969	-.006	.969	1.93	.169	.215	.169
Infant Age	.013	.910	.027	.910	2.05	.157	-.238	.157
Relationship x Minutes	.114	.737	-.075	.737	.002	.968	.009	.968
Minutes x Age	.732	.396	.164	.396	4.62	.035	-.364	.035
Relationship x Age	.537	.466	.109	.466	.149	.701	.057	.701
Relationship x Minutes x Age	2.66	.108	-.451	.108	.113	.737	.091	.737
Fatigue	2.37	.129	-.120	.129	1.05	.309	.083	.309
Time of Day	.001	.970	-.004	.970	.690	.409	.111	.409

Trimmed	**Pleasure df=(1, 63)**				**Connection df= (1, 66)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	.226	.636	.068	.636	6.63	.012	.316	.012
Minutes Since Breastfed	.144	.706	-.048	.706	1.94	.169	.193	.169
Infant Age	.277	.600	-.091	.600	1.44	.234	-.182	.234
Relationship x Minutes	.142	.707	.067	.707	----	----	----	----
Minutes x Age	2.20	.143	.184	.143	8.22	.006	-.337	.006
Relationship x Age	.003	.959	-.006	.959	----	----	----	----
Relationship x Minutes x Age	2.40	.126	-.322	.126	----	----	----	----
Fatigue	.644	.425	-.078	.425	1.00	.321	.083	.321
Time of Day	----	----	----	----	----	----	----	----

Note. Minutes since breastfed shows the change for every minute increase.

Table 9. Initial and trimmed model results of generalized linear mixed model regression analyses on sexual frequency in breastfeeders and in the entire group. Current relationship quality, in-pair sexual desire, partner attractiveness, resumption of menstruation, fatigue, and infant age were possible predictors.

	Frequency of Sex Breastfeeders (n=76) df=(1, 70)				**Frequency of Sex Breastfeeders Trimmed (n=76) df=(1, 72)**			
	F	**p**	**B**	**P**	***F***	**p**	**B**	p
Current Relationship Quality	.447	.506	.126	.506	----	----	----	----
In-Pair Sexual Desire	7.46	.008	.297	.008	8.64	.004	.315	.004
Fatigue	.042	.839	.014	.839	----	----	----	----
Partner Attractiveness	.001	.975	.005	.975	----	----	----	----
Resumption of Menstruation	1.28	.262	.356	.262	.187	.667	.127	.667
Infant Age	.928	.339	.148	.339	1.44	.235	.181	.235

Note. Resumption of menstruation shows the change from menstruating to not menstruating.

	Frequency of Sex All Initial (n=104) df=(1, 97)				**Frequency of Sex All Trimmed (n=104) df=(1, 99)**			
	F	**p**	**B**	**P**	***F***	**p**	**B**	p
Current Relationship Quality	1.28	.260	.207	.260	.313	.577	.072	.577
In-Pair Sexual Desire	6.39	.013	.262	.013	5.85	.017	.259	.017
Fatigue	.459	.500	.046	.500	----	----	----	----
Partner Attractiveness	.005	.944	.012	.944	----	----	----	----
Resumption of Menstruation	2.99	.087	.458	.087	1.50	.223	.312	.223
Infant Age	.817	.368	.124	.368	1.16	.283	.154	.283

Note. Resumption of menstruation shows the change from menstruating to not menstruating.

.

Table 10. Model results of generalized linear mixed model regression analyses on the frequency of sexual activity. Pleasure-related motivations and partner-connection motivations are predictors.

Breastfeeders	**Frequency of Sex (n=72) df= (1, 69)**			
	F	**p**	**B**	**P**
Pleasure	.010	.922	.018	.922
Partner-connection	.287	.594	.072	.594

All cases	**Frequency of Sex (n=100) df= (1, 97)**			
	F	p	B	P
Pleasure	2.97	.088	.245	.088
Partner-connection	.211	.647	-.061	.647

Table 11. Initial and Trimmed model results of generalized linear mixed model regression analyses on in-pair and extra-pair sexual desire for all mothers. Fatigue, current relationship quality, partner attractiveness, resumption of menstruation, infant age, and time of day are predictors in the first section.

Initial Model	**In-pair Sexual Desire (n=106) df=(1, 99)**				**Extra-pair Sexual Desire (n=106) df= (1, 99)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	1.63	.205	.172	.205	4.50	.036	-.260	.036
Fatigue	.750	.389	-.068	.389	3.81	.054	-.081	.054
Partner Attractiveness	.178	.674	.068	.674	.469	.495	-.069	.495
Resumption of Menstruation	.499	.481	-.177	.481	6.83	.010	-.465	.010
Infant Age	3.88	.052	-.283	.052	11.4	.001	-.295	.001
Time of Day	.090	.765	.037	.765	.040	.935	.018	.935
Trimmed Model	**In-pair Sexual Desire df=(1, 102)**				**Extra-pair Sexual Desire df=(1, 101)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	2.03	.157	.180	.157	5.32	.023	-.212	.023
Fatigue	.721	.398	-.066	.398	4.53	.036	-.096	.036
Partner Attractiveness	----	----	----	----	----	----	----	----
Resumption of Menstruation	----	----	----	----	5.94	.017	-.463	.017
Infant Age	4.02	.048	-.283	.048	10.6	.002	-.297	.002
Time of Day	----	----	----	----	----	----	----	----

Additional notes. Resumption of menstruation shows the change from menstruating to not menstruating.

Table 12. Initial and trimmed model results of generalized linear mixed model regression analyses on pleasure sexual motivations and partner-connection sexual motivations following breastfeeding. Current relationship quality, in-pair sexual desire, fatigue, partner attractiveness, resumption of menstruation, infant age, and time of day are predictors in the initial model.

Initial Model	**Pleasure (n=101) df=(1, 93)**				**Connection (n=101) df=(1, 93)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
Relationship Quality	1.81	.182	.159	.182	11.9	.001	.336	.001
Fatigue	2.12	.149	-.106	.149	.400	.529	.034	.529
Partner Attractiveness	.001	.971	-.006	.971	4.29	.041	.259	.041
Resumption of Menstruation	.812	.370	-.183	.370	5.98	.016	-.439	.016
In-pair Sexual Desire	5.45	.022	.174	.022	7.50	.007	.274	.007
Infant Age	.025	.875	-.023	.875	.287	.593	-.075	.593
Time of Day	.634	.428	.069	.428	1.42	.237	.110	.237

Trimmed Model	**Pleasure df=(1, 95)**				**Connection df= (1,95)**			
	F	p	B	p	*F*	p	B	p
Relationship Quality	1.57	.213	.132	.213	9.57	.003	.309	.003
Fatigue	2.15	.146	-.109	.146	----	----	----	----
Partner Attractiveness	----	----	----	----	9.04	.003	.339	.003
Resumption of Menstruation	.843	.361	-.183	.361	3.82	.054	-.364	.054
In-Pair Sexual Desire	5.98	.016	.182	.016	9.10	.003	.234	.003
Infant Age	----	----	----	----	----	----	----	----
Time of Day	.723	.397	.074	.397	2.14	.147	.339	.147

Note. Resumption of Menstruation coefficients show the change from menstruating to not menstruating.

Table 13. Model results of generalized linear mixed model regression analyses on pleasure sexual motivations, partner-connection sexual motivations, and frequency of sex using in-pair and extra-pair sexual desire predictors.

Sexual Motivation	**Pleasure (n=101) df= (1, 98)**				**Connection (n=101) df=(1, 98)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
In-Pair Desire	8.95	.004	.226	.004	10.5	.002	.394	.002
Extra-Pair Desire	.485	.488	-.048	.488	.293	.590	-.032	.590

Sexual Frequency	**Frequency of Sex (n=104) df=(1, 101)**			
	F	p	B	p
In-Pair Desire	6.03	.016	.259	.016
Extra-Pair Desire	.647	.423	-.080	.423

Table 14. Model results of generalized linear mixed model regression analyses on the frequency of sexual activity. Type of feeding, pleasure-related sexual motivation, and the type of feeding by pleasure-related sexual motivation interaction were included as predictions.

	All cases Frequency of Sex (n=100) df=(1, 96)			
	F	p	B	p
Pleasure	2.62	.109	.147	.282
Type of Feeding	6.02	.016	.657	.016
Pleasure by Type of Feeding	.444	.507	.171	.507

Note. Type of feeding shows the change from breastfeeding to bottle-feeding.

Table 15. Model results of generalized linear mixed model regression analyses on in-pair and extra-pair sexual desire using time since fed (or minutes since fed), type of feeding, infant age, and their interactions as predictors.

Time as Predictor	**In-pair Sexual Desire (n=106) df=(1, 98)**				**Extra-pair Sexual Desire (n=106) df=(1, 98)**			
	F	p	B	p	*F*	p	B	p
Time Since Fed	.724	.397	-.247	.091	.202	.654	-.041	.853
Type of Feeding	.025	.875	-.324	.317	.477	.491	.226	.499
Infant Age	3.74	.056	-.296	.097	6.24	.014	-.199	.259
Time Since Fed x Type of Feeding	6.62	.012	.737	.012	.070	.792	-.116	.792
Type of Feeding x Infant Age	.000	.994	.151	.595	.499	.481	-.062	.843
Time Since Fed x Infant Age	1.40	.240	-.005	.975	.377	.541	-.353	.134
Time Since Fed x Type of Feeding x Infant Age	1.30	.258	-.306	.258	1.16	.283	.450	.283

Minutes as Predictor	**In-pair Sexual Desire (n=106) df=(1, 98)**				**Extra-pair Sexual Desire (n=106) df=(1, 98)**			
	F	p	B	p	*F*	p	B	p
Minutes Since Fed	.225	.636	.152	.161	.010	.921	-.070	.640
Type of Feeding	.620	.433	.240	.433	.495	.483	.174	.483
Infant Age	5.98	.016	-.358	.027	5.82	.018	-.366	.007
Minutes Since Fed x Type of Feeding	3.45	.066	-.408	.066	.115	.735	.109	.735
Type of Feeding x Infant Age	.039	.844	-.055	.844	.435	.511	.154	.511
Minutes Since Fed x Infant Age	.783	.378	-.122	.187	.013	.909	.083	.510
Minutes Since Fed x Type of Feeding x Infant Age	4.19	.043	.429	.043	.171	.680	-.130	.680

Notes. Time Since Breastfed coefficients show the change from 120 minutes to 20 minutes. Minutes since fed shows the change for every minute increase. Type of feeding coefficients show the change from bottle-fed to breastfed.

Table 16. Model results of generalized linear mixed model regression analyses on pleasure sexual motivations and partner-connection sexual motivations using time since fed (or minutes since fed), type of feeding, infant age, and their interactions as predictors.

Time as predictor	**Pleasure (n=102) df= (1, 94)**				**Connection (n=102) df=(1, 94)**			
	F	**p**	**B**	**p**	***F***	**p**	**B**	**p**
Time Since Fed	.098	.755	-.022	.836	.024	.877	-.125	.308
Type of Feeding	.123	.727	.096	.722	.642	.425	-.357	.230
Infant Age	.560	.456	-.066	.673	1.05	.307	-.232	.166
Time Since Fed x Type of Feeding	.009	.926	-.019	.926	1.47	.229	.285	.229
Type of Feeding x Infant age	.033	.402	-.044	.847	.459	.500	.098	.696
Time Since Fed x Infant Age	.116	.734	-.113	.321	.332	.566	.314	.018
Time Since Fed x Type of Feeding x Infant Age	.708	.402	.162	.402	5.12	.026	-.502	.026

Minutes as predictor	**Pleasure (n=102) df=(1, 94)**				**Connection (n=102) df=(1, 94)**			
	F	p	B	p	*F*	p	B	p
Minutes Since Fed	.034	.855	-.016	.827	.236	.628	.201	.021
Type of Feeding	.261	.610	.144	.610	.227	.635	-.125	.635
Infant Age	.613	.436	-.183	.285	1.16	.284	-.076	.654
Minutes Since Fed x Type of Feeding	.164	.687	.059	.687	3.63	.060	-.321	.060
Type of Feeding x Infant Age	.097	.756	.096	.756	.941	.334	-.216	.334
Minutes Since Fed x Infant Age	.256	.614	.068	.290	.901	.345	-.285	.000
Minutes Since Fed x Type of Feeding x Infant Age	.233	.630	-.066	.630	6.89	.010	.420	.010

Note. Time Since Breastfed coefficients show the change from 120 minutes to 20 minutes. Minutes since fed shows the change for every minute increase. Type of feeding coefficients show the change from bottle-fed to breastfed.