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Is Postpartum Depression a Disease of Modern Civilization?

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POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

Abstract

Access to calorie-dense foods, medicine and other comforts make modern humans healthier than our prehistoric ancestors in many respects. However, the epidemics of obesity, diabetes, and cardiovascular disease suggest that there are also drawbacks to modern living. Here we address the question of whether the dramatic cultural changes that have occurred over the last century have inflated rates of postpartum depression, adding postpartum depression to the list of “diseases of modern civilization.” We review evidence from cross-cultural, epidemiological, and experimental studies documenting associations between postpartum depression and modern patterns of early weaning, diets deficient in essential fatty acids, low levels of physical activity, low levels of sun exposure, and isolation from kin support networks, all of which diverge significantly from lifestyles believed to be typical throughout human evolutionary history. This mismatch hypothesis of postpartum depression integrates research across diverse research areas and generates novel predictions.

Keywords: Postpartum Depression; Evolutionary Medicine; Omega-3 Fatty Acids; Social Support; Exercise

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

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Common maladies, such as cardiovascular disease, diabetes, and even tooth cavities are rare in societies characterized by lifestyles resembling those of the human ancestral past (Gluckman & Hanson, 2006). These “diseases of modern civilization” are thought to largely result from *mismatches* between the modern world and the ancient environments to which humans are adapted. Here, we propose that such a mismatch might also account for an increased prevalence of postpartum depression today.

Approximately 13% percent of women worldwide will experience depressive symptoms within the first three times cross-cultural, epidemiological, and experimental studies documenting associations between postpartum depression and early weaning, diets deficient in essential fatty acids, low levels of physical activity, and isolation from kin support networks, all of which are typical of modern parenting practices but were probably rare in the human evolutionary past.

In framing this *mismatch hypothesis of postpartum depression*, we draw on previous evolutionary mismatch frameworks for understanding diseases of modern civilization (see Gluckman & Hanson, 2006; Nesse & Williams, 1996, in addition to the “PATHOS” model (Raison, & Miller, 2012), which conceptualizes depressive symptoms as a evolutionarily functional suite of sickness-like behaviors employed to decrease activity and increase vigilance when the body’s immune system is activated in response to disease or stress (Dantzer et al., 2008). Inflammation leads to signaling in the brain that can trigger the development of symptoms of depression and other sickness-like behaviors (Dantzer et al., 2008). Although there are many mechanisms underling the relationships between the diverse risk factors we discuss here and

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

postpartum depression, a striking underlying theme is that most have been linked to heightened inflammatory processes during pregnancy or the postpartum.

Dietary Mismatches

Although hunter-gather diets varied significantly on a geographical, cultural, and seasonal basis, scientists have pieced together a picture of the preagricultural ancestral diet from chemical analysis of human skeletal remains and archaeological excavation of living sites. From these sources of evidence, it appears that the preagricultural human diet was comprised of wild meats (~30% of calories), starchy tubers (~30% of calories), and seasonal fresh fruits and vegetables (~30%) (see Eaton, 2006, for a review). Ancestral diets tended to be richer in essential micronutrients, fiber, and fatty acids than western diets (Eaton, 2006), although were not necessarily better across the board, as periods of food shortage and caloric restriction were probably more common. The agricultural revolution 10,000 years ago afforded humans the potential to grow and store large quantities of energetically-rich grains. Modern diets displace more micro-nutrient dense, perishable foods with grains as the primary food source (Eaton, 2006). This pattern has led researchers to conclude that many modern populations are overfed yet undernourished (Gluckman & Hanson, 2006).

For example, western diets are relatively low in omega-3 essential fatty acids (Eaton, 2006). These “good fats” make up 20% of the human brain by volume, have potent anti-inflammatory effects (Simopoulos, 1991), and were prevalent in wild-caught organ meats regularly consumed by preagricultural humans (Eaton, 2006). The primary protein source in Westernized countries, by contrast, are muscle meats derived from grain-fed livestock, which have lower levels of fat, generally, and much lower levels of omega 3 fatty acids than meats from wild caught game living on their own ancestrally-typical diets (Eaton, 2006). Further, staple

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

fat sources in the western diet (e.g., dairy and vegetable oils), while rich in essential unsaturated omega 6 fatty acids, contain little to no omega 3 fatty acids. The “good fat gap” characteristic of modern diets is exacerbated by pregnancy and lactation because already scarce maternal stores are tapped to supply the developing infant (De Vriese, Christophe, Maes, 2003). The potential link between omega 3s and postpartum depression is reinforced by a recent study that aggregated the results of 29 earlier randomized control trials (e.g. meta-analysis) and found that omega-3 fatty acid supplementation is effective in resolving existing cases of depression (Appleton, Rogers, & Ness, 2010).

Seafood is high in omega-3 fatty acids, and rates of postpartum depression cross-culturally are negatively related to pounds of seafood consumed per person per year (see figure 1; reprinted from Habbeln, 2002). In addition, several large epidemiological studies find correlations between higher circulating omega-3 fatty acid levels in pregnancy and reduced risk for postpartum depression (see Markhus et al., 2013, for a review), although one large randomized controlled trial showed only a small and non-significant reduction in rates of postpartum depression from 3 fatty acid supplementation in pregnancy (Makrides et al., 2010).

Additional research is needed to study other major dietary discontinuities that may be impacting rates of postpartum depression today. Discontinuities like carbohydrate-laden/sugar rich diets and over-feeding, and resultant type 2 diabetes and obesity, for example, have been linked to chronic inflammation and depression outside the context of pregnancy (Capuron et al., 2008) and were not problems encountered often by our ancestors

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

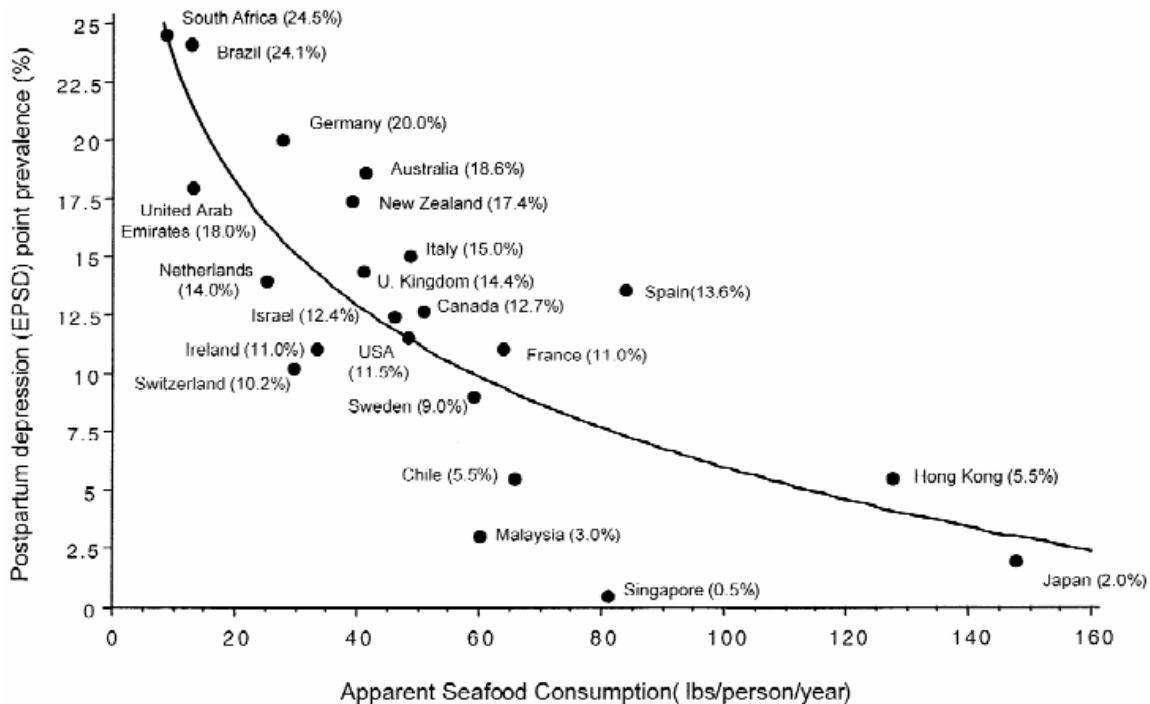


Fig 1. Reprinted from Hibbeln (2002). *Seafood consumption and prevalence rates of postpartum depression by country*. Graph shows the inverse correlation between pounds of seafood consumption per year and prevalence in rates of postpartum depression by country. This association remained significant after adjusting for gross domestic product (GDP) and after removing outing Asian nations (which systematically differ in both high seafood consumption and low rates of postpartum depression).

Breastfeeding Mismatches

Breastfeeding is an ancient mammalian adaptation that dramatically changes maternal hormone profiles in ways that are likely to facilitate mothers' postpartum adjustment. However, breastfeeding rates are much lower today than they were for the vast majority of human history. Stable nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotopes unique to breast milk, and detectable in prehistoric fossils, suggest that prehistoric infants were primarily fed breast milk for the first 1.5 years of life, and were weaned, on average, sometime between 2 and 4 years of age (Clayton, Sealy, & Pfeiffer, 2006). A review of 64 small-scale societies places weaning between 2-4 years,

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

providing converging evidence of the duration of species-typical lactation for humans (Dettwyler, 1995). By contrast with these estimates, just over 30% of infants in the United States are breastfed until 6 month of age, and approximately 20% of mothers never initiate breastfeeding (McDowell, Wang, & Kennedy-Stephenson, 2008). Could this dramatic change in breastfeeding influence rates of postpartum depression?

Surprisingly little research directly addresses this question, but several biological effects of breastfeeding provide plausible biological pathways through which breastfeeding could be protective (see Hahn-Holbrook, Glynn, Haselton, & Dunkel Schetter, 2013, for a review). For example, breastfeeding releases the hormones oxytocin and prolactin, each of which have anxiolytic properties and have been found in lower levels in women with depressive symptomatology postpartum than in women without such symptoms (Skrundz et al., 2011; Zonana & Gorman, 2005). Experimental studies in rats and correlational studies in humans find that, compared with nonlactating mothers, lactating mothers show a reduced inflammatory reaction to stress, which might protect against depressive symptoms (Groer & Davis, 2006; Jaedicke, Fuhrmann & Stefanski, 2009). Further, breastfeeding is associated with a reduced incidence of health problems in infants and mothers over the long-term, each of which could yield positive downstream consequences for maternal mental health (Hahn-Holbrook et al., 2013).

In line with the premise that breastfeeding might offer mental health benefits, in the only true experiment on breastfeeding and mood in humans, women currently using both breastfeeding and formula-feeding methods reported lower levels of negative affect when randomly assigned to breastfeed versus formula feed their baby in the lab (Mezzacappa, & Katlin, 2002). Further, 12 cross-sectional studies have found lower incidences of depressive

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

symptomatology amongst women who breastfeed as compared with woman who exclusively formula-feed (see Dennis & McQueen, 2009, for a review). From these correlational data one cannot conclude that that breastfeeding offers mental health benefits; an alternative hypothesis seems equally plausible – that women who are depressed are simply less likely to breastfeed (Dennis & McQueen, 2009). Recently, however, two longitudinal studies were able to examine whether breastfeeding preceded and predicted a reduced risk of depression. These studies showed that breastfeeding fewer times per day at 3 months (Hahn-Holbrook et al., 2013) and weaning before 6 months (Ystrom, 2012) predicted higher risk of postpartum depression later in the postpartum, in line with the possibility that breastfeeding might have a protective effect (but see Dennis & McQueen, 2007 for a null result). Given the evidence, we hypothesize that the high rates of postpartum depression seen today may be a by-product of the fact that mothers are dealing with the challenge of caring for a new infant without getting the stress regulation and bonding benefits of breastfeeding, a position that should not be confused with a previous adaptationist account which proposes that, by not breastfeeding, a women’s body mistakenly triggers a grieving adaption designed for cases where the mother has weaned because her child has died (Gallup et al. 2010).

Exercise Mismatches

There is little doubt that modern humans, particularly in the West, get less exercise than did humans throughout much of evolutionary history. After the introduction of mechanized farming technologies, for example, the total basal metabolic demands of farm workers were reduced by 50% in Japan and 65% in Britain (Eaton, Eaton & Konnor, 1997). Moreover, contemporary hunter-gathers burn an estimated 3,000 calories a day, as compared with an estimated 2,000 calories a day for adults in the US (Eaton, Eaton & Konnor, 1997).

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

Exercise acts on multiple biological pathways thought to influence depression, including chronic inflammation, insulin resistance, and serotonergic and dopaminergic activity (Lucassen et al., 2010). Moreover, these biological systems undergo dramatic changes during pregnancy and lactation (Elenkov et al., 2001), raising the possibility that exercise-induced regulation of these systems might be even more important during the postpartum transition. In line with this view, a meta-analysis of five randomized controlled trials showed that exercise interventions produced reductions in rates of postpartum depression in comparison to non-active or social support group controls (Daley, Jolly, & MacArthur, 2009). This result echoes results from a larger meta-analysis of 11 studies documenting decreases in general clinical depression after exercise interventions as compared with controls (Stathopoulou, Powers, Berry, Smits, & Otto, 2006).

Sun Exposure Mismatches

Sun exposure is the primary source of vitamin D synthesis in humans and modern humans are increasingly sheltered from the sun. This discontinuity has led to a modern day epidemic of vitamin D deficiency (Dawidu & Wagner, 2007). Eighteen percent of pregnant woman in the United Kingdom, 25% in the United Arab Emirates, 42% in northern India, 45% of African American women in the United States, 61% in New Zealand, and 60-84% of non-western women in the Netherlands have circulating levels of vitamin D below the cutoff of 25(OH)D (Dawidu & Wagner, 2007). Shortfalls in vitamin D are exacerbated by the increased nutritional demands of pregnancy and lactation, which have lead to outbreaks of rickets amongst some breast-fed US infants (Arora & Hobel, 2010).

Vitamin D acts on the immune system by stimulating antimicrobial responses that suppress inflammation (Arora & Hobel, 2010). Hence, vitamin D deficiency during pregnancy increases mothers' susceptibility to infections, inflammation, and pregnancy complications

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

(Arora & Hobel, 2010), potentially leading to postpartum depression. Consistent with this notion, a cross-sectional study of 176 pregnant African American women found that vitamin D deficiency was associated with depressive symptoms (Cassidy-Bushrow, et al., 2012). Although there are no vitamin D intervention studies that assess depression in pregnancy or the postpartum, a double blind randomized controlled trial in overweight and obese adults showed that vitamin D supplementation led to a significant improvement in depressive symptoms, and a meta-analysis of numerous correlational studies reported a similar association (Anglin, Samaan, Walter, & McDonald, 2013).

Child-care Mismatches

Hunter-gather families typically live in multigenerational kin groups, in which grandparents, aunts and uncles, and older siblings assist mothers and fathers with their young children (Bukart, Hrdy, & Van Schaik, 2009). In contrast, in the Western world, nuclear families are often living hundreds or thousands of miles away from these helping hands. Further, western families are having fewer children spaced closer together in age, simultaneously making it less likely that older siblings will be available to help with child care and more likely mothers will be burdened with caring for two very young children at the same time. Meta-analysis shows that weak or absent social support is one of the most consistent predictors of postpartum depression (O'Hara & Swain, 1996). Therefore, the shift from multigenerational families to smaller nuclear families could have dramatic impacts on women's ability to cope with the demands of motherhood.

The "latina paradox" provides additional evidence suggesting the crucial importance familial support might offer to mothers. The paradox is that mothers who emigrate from Mexico to the United States have lower rates of postpartum depression, on average, than white mothers, even

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

though immigrant mothers are more likely to live in poverty and be single (Campos et al., 2008). The primary factor thought to account for this surprising finding is the high degree of family and community support that these Latina women experience, compared to economically richer but more isolated white women (Campos et al., 2008). Further, in a longitudinal study of 210 women from diverse economic and ethnic backgrounds, maternal support from family, but not the baby's father, buffered mother's against increases in the stress hormone-placental corticotrophin releasing hormone in pregnancy, reducing their risk for postpartum depression (Hahn-Holbrook, Dunkel Schetter, Arora, & Hobel, 2013).

In a practical sense, nannies, babysitters, and daycare centers can take the place of extended family childcare networks. However, these modern stand-ins might not be able to replace the emotional support provided by family important for maternal coping postpartum.

Other Risk Factors

We believe the evidence for the discontinuity hypothesis is compelling and helps explain the high rates of postpartum depression seen today in the wealthiest nations in the world. However, we acknowledge that many risk factors for postpartum depression are probably not more common today than they were in the ancestral past (e.g. chronic life stress, father abandonment, infant health problems, history of depression). These factors are likely to have other etiological relationships with postpartum depression and different evolutionary foundations than the associations we have described (see Hagen, 1999 and O'Hara & Swain, 1996, for reviews). In sum, we argue that the mismatch hypothesis of postpartum depression is an important – if incomplete – account for cases of postpartum depression.

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

Conclusion

The mismatch hypothesis of postpartum depression can serve as a guide for future research. For example, one prediction of it is that rates of postpartum depression will vary cross-culturally with differences in breastfeeding, traditional diets, active lifestyles, daily sun exposure, and the existence of multi-generational households. Further, although there is substantial evidence of associations between a variety of modern factors and increased risk for postpartum depression, much more research is needed to establish *causal* relationships between these factors and postpartum depression and to develop and test potential interventions. Some interventions suggested by this mismatch hypothesis are particularly promising because of their simplicity, such as vitamin D and omega 3 fatty acids supplementation during pregnancy. This framework also suggests that some medical advice given to pregnant women, for example, to avoid sun exposure (to prevent skin cancer) and limit fish consumption (because of mercury exposure) might be counter productive in the fight against postpartum depression. Other interventions, such as increasing breastfeeding and exercise postpartum, might be much more challenging to implement, because of multiple competing demands on mothers' time. Our hope is that the mismatch hypothesis framework will trigger additional research and identify interventions that bridge the gap between women's evolved biology and modern life.

Recommended Readings

A related article describing the rise in rates of major depressive disorder as a function of modern living: Hidaka, B.H. (2012). Depression as a disease of modernity: Explanations for increasing prevalence. *Journal of Affective Disorders*, 140, 205-214.

A classic book outlining evolutionary approaches to understanding human disease: Nesse, R. M. & Williams, G. C. (1996). *Why We Get Sick: The New Science of Darwinian Medicine*. Random House Digital, Inc.

An overview of the role of inflammation in the etiology of depression: Dantzer, R., O'Connor, J. C., Freund, G. G., Johnson, R. W., & Kelley, K. W. (2008). From inflammation to sickness and depression: when the immune system subjugates the brain. *Nature Reviews Neuroscience*, 9(1), 46-56.

An assessable book that discusses the important role that kin and other group members likely played in raising offspring throughout human evolutionary history and the potential consequences this has for women today: Hrdy, S. B. (2009). *Mothers and others*. Belknap Press.

A recent review of research on maternal mental health and breastfeeding:

Hahn-Holbrook, J., Dunkel Schetter, C., & Haselton, M. (2013). The advantages and disadvantages of breastfeeding for maternal mental and physical health (pp. 414-439). In M. Spiers, P. Geller & J. Kloss (Eds.), *Women's Health Psychology*. New Jersey: Wiley.

POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

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POSTPARTUM DEPRESSION A DISEASE OF MODERN CIVILIZATION?

Figure Captions

Figure 1. *Reprinted from Hibbeln (2002). Seafood consumption and prevalence rates of postpartum depression by country. Postpartum prevalence rates for Australia, New Zealand, Sweden and the United Kingdom, The United States were derived by meta-analysis. All other countries are represented by a single study. Apparent Seafood consumption lb/person/year is an economic measure of disappearance of all fin and seafood from the economy and is calculated by imports plus catch minus exports. A logarithmic regression was used for analysis ($r = -.81$, $p = 0.001$).*