Molecules and Cells

Journal Club

Don’t Worry, Heavy Moms; Just Eat Your Broccoli (or Kimchi)!

Co-diet of high-fiber and high-fat helps give birth to healthy offspring through gut microbiota-to-brain signaling

Sun-Kyung Lee*

Department of Life Sciences, Research Institute for Natural Sciences, College of Natural Sciences, Hanyang University, Seoul 04763, Korea
*Correspondence: sunkyungl@hanyang.ac.kr
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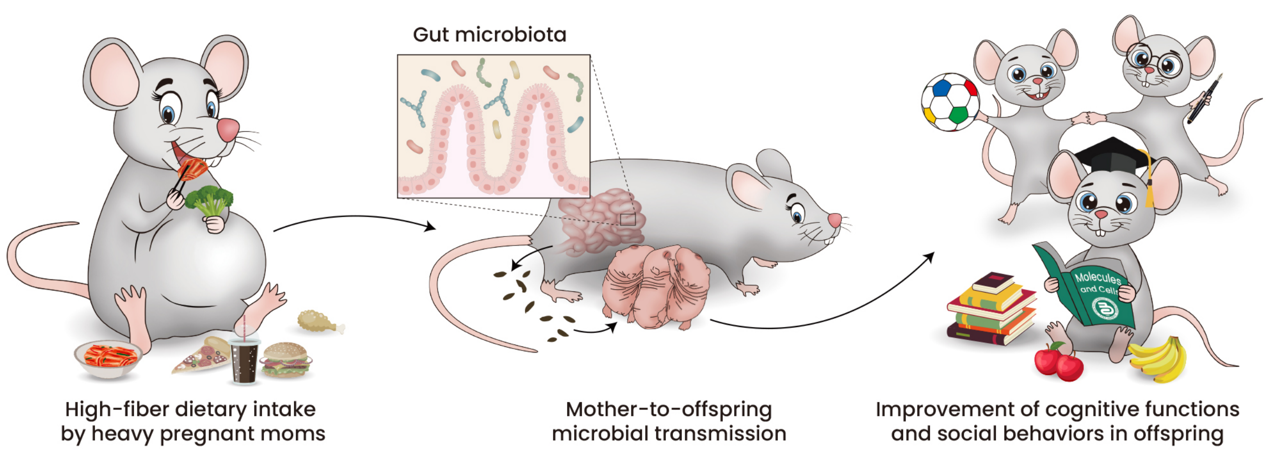

High-fiber diet can help heavy pregnant mothers bear smarter and friendlier children by promoting a healthy gut microbiome that is transmitted through the consumption of feces.

No doubt it is that maternal health is an absolute influencer for the well-being of the offspring. Especially, a mother's fitness plays a critical role in not only children's physical health but also their mental health. Maternal obesity before and during pregnancy adversely affects the health outcomes of children in both the short and long terms, leading to higher risks of chronic diseases, such as diabetes and high blood pressure, and behavioral changes, including cognitive performance and social activities (Godfrey et al., 2017). Recently, changes in the gut microbiome of obese mothers have been

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in the spotlight because of their causal effects of maternal obesity on offspring outcomes (Buffington et al., 2016). A high-fiber diet is a game changer that promotes diversity of the gut microbiota and the production of short-chain fatty acids (SCFAs) (e.g., acetate, propionate, and butyrate), which exert beneficial effects on the physiology of the host and its offspring (Silva et al., 2020). Liu et al. (2021) have provided additional evidence that a high-fiber diet can help obese mothers bear smarter and friendlier children.

The brain signals the gut to properly function, and neurological stressors interfere with gut functions, such as motility, secretion, blood flow, and immune activities (Fung et al., 2017). Moreover, the brain-to-gut signaling can directly influence the gut microbiota, and people with brain disorders, such as autism spectrum and Alzheimer's disease, have an imbalanced composition in their gut microbiome (Ho et al., 2018; Kelly et al., 2017; Sharon et al., 2016). The gut microbiota exhibit extraordinary densities, including trillions of bacteria, and significantly influence human health and disease development and progress (Lynch and Pedersen, 2016). Changes in maternal microbiome induced by antibiotics and diet during pregnancy can modulate offspring microbiome, neurodevelopment, and behaviors (Sharon et al., 2016; 2019). The gut microbiota can signal the brain in a bidirectional mode through many pathways involving nerves and metabolites (Fung et al., 2017). Recently, their production of SCFAs by fermenting dietary fibers has drawn much attention because of the ability of SCFAs to nourish and stimulate the brain. Therefore, microbiota manipulation and SCFA administration have been proposed to treat neurodevelopmental disorders accompanying imbalanced gut microbiota.

The research team performed a cohort study that examined the association between maternal pre-pregnancy obesity and long-term child neurodevelopment. In the study, 778 children from urban cities in Eastern China whose mothers' pre-pregnancy body mass index was known were enrolled, and then their social competence were followed up by grading activities (e.g., sports and hobbies), social subjects (e.g., friendship and interpersonal skills), and school performance (e.g., learning ability). Few Asian cohort study has revealed that children of obese mothers scored significantly lower in social competence than those of normal-weight mothers.

To investigate how maternal obesity affects the neuro-behavioral development of offspring, Liu et al. (2021) have fed female mice with a high-fat diet and then observed their offspring's behavior. Despite consuming a regular diet after weaning, the offspring of mothers fed with a high-fat diet showed impaired working and long-term memories and were less willing to explore new spaces or objects. They did not tell a new friend from an old friend, exhibiting no preference for social novelty. The behavioral impairment was associated with reduced post-synaptic density (PSD) in the brain and the low expression of various genes involved in synaptic plasticity and brain development.

To assess the effects of dietary fiber, the team simultaneously fed female mice with both a high-fat diet and a diet with high content of inulin, a prebiotic soluble fiber, and then compared their offspring's behaviors with those of the offspring of controls. The offspring of mice fed with a high-fat and high-inulin co-diet showed strikingly improved memories and social activities. Moreover, their reduced PSD size and neuro-developmental gene expression changes were restored.

Aware of that maternal high-fiber dietary intake protects offspring from dysfunctional neurodevelopment, Liu et al. (2021) have examined whether the protection is correlated with gut microbiota changes. Maternal high-fiber diet corrected high-fat diet-induced changes in the composition of the gut microbiome not only in mothers but also in the offspring. Interestingly, particular bacterial families were prevalent in the microbiome induced by maternal high-fiber diet. Significantly, five bacterial operational taxonomic units in S24-7 families differentiating in the offspring were positively correlated with improved cognitive and social behaviors. This finding suggests that introducing particular bacterial strains into the gut microbiome improves cognitive behaviors and sociability.

Strikingly, the offspring of mothers fed with a high-fat diet reared by mothers fed with a high-fiber diet or co-housed with the offspring of mothers fed with a high-fiber diet showed improved cognitive behaviors and social activities because the gut microbiome can be transferred by vertical transmission from a mother to an offspring or by the ingestion of feces.

Moreover, a high-fiber diet after weaning reshaped the gut microbiome in the offspring of mothers fed with a high-fat diet. S24-7 families and *Bacteroides* positively correlated with improved cognitive and social activities are enriched, but negatively correlated *Ruminococcus* is depleted. The high-fiber diet for offspring of mothers fed with a high-fat diet also corrected the altered gene expression in pathways involving transcription, translation, protein quality control and export, and RNA processing by the spliceosome in the hippocampus, the brain region responsible for learning and memory. Dietary fiber intake elevated SCFA levels in the offspring of mothers fed with a high-fat diet. Furthermore, the levels of acetate and propionate were significantly correlated with the most differentiating bacterial taxa. Supplementing acetate and propionate in drinking water of offspring born to obese mothers remarkably improved their cognition and sociability, restored the reduced size of the PSD and the decreased expression of genes related to neurodevelopment, and promoted microglial maturation and activities, and synaptic function.

Maternal obesity reduces microbial diversity in offspring, and the selective re-introduction of *Lactobacillus* restores offspring social deficits (Buffington et al., 2016). Also, maternal exercise greatly induces the accumulation of the prebiotic oligosaccharide 3'-sialyl lactose (3'-SL) in milk, which helps prevent metabolic disorders, such as diabetes and cardiovascular diseases, in offspring (Harris et al., 2020). Despite some limitations, such as limited cohort selection and missing litter analyses, and uncertain effects of lactation, Liu et al. (2021) have added a shred of compelling evidence that indicates the causal relationship between maternal gut microbiota composition and behavioral changes in offspring, using a co-diet regimen of high-fiber and high-fat. Investigation for the underlying molecular mechanism and signaling pathways indeed awaits further studies. For the time being, expecting moms who are struggling to cut off fries and potato chips or consistently work their butt off at the gym will be blessed by munching on broccoli. What about kimchi? The traditional Korean fermented veggie is a great source of *Lactobacillus* and other beneficial probiotics, in addition to dietary fiber, which may work even better (Lim et al., 2020). It is definitely worth making the heavenly tasty easy-to-come-by.

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CONFLICT OF INTEREST

The author has no potential conflicts of interest to disclose.

ORCID

Sun-Kyung Lee https://orcid.org/0000-0001-5368-0722

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