

### Dietary Patterns, Fiber Intake and Microbial-Derived Isobutyrate Are Associated With Executive Function in Toddlerhood

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**Objectives:** Early childhood is characterized by stabilization of the gut microbiome and rapid maturation of executive functions (EF; cognitive flexibility [F]; inhibitory self-control [ISC]; emergent metacognition [EM]), which are vital to the regulation of goal-directed behaviors, academic and social success. While diet in school-aged children and gut microbial-derived volatile fatty acids (VFA) in rodent models are linked to EFs, few studies have explored these in early life among humans. The present study investigated the extent to which dietary patterns, fiber intake and fecal VFA predict EF at 24 mo.

**Methods:** Parents and 24-mo-old children ( $N = 291$ ) were recruited from the STRONG Kids 2 cohort study. Parent reported surveys were used to assess EF (Behavioral Rating Inventory of Executive Function for Preschoolers) and diet (Block Food Frequency Questionnaires). To derive dietary patterns, raw frequency responses for diet were used to create 23 food groups, which were input into principle component

analysis. Analyses were independent of sex, socioeconomic status and energy intake.

**Results:** Two distinct dietary patterns explaining 30% of the overall variance in diet were evident: higher consumption of fried and sweet foods (DP1) and of vegetables and fruits (DP2). On average, toddlers consumed below the recommendation for fiber intake, 9.10 g/1000 kcals per day. Higher DP1 scores were associated with poorer overall and construct-specific EF (EF:  $b = 6.146$ ,  $p = 0.005$ ; ISC:  $b = 4.458$ ,  $p = 0.032$ ; F:  $b = 4.522$ ,  $p = 0.019$ ; EM:  $b = 7.322$ ,  $p = 0.002$ ). DP2 was not associated with EF. Toddlers with lower energy-adjusted fiber intake had significantly poorer EF (EF:  $b = -1.696$ ,  $p = 0.009$ ; ISC:  $b = -1.729$ ,  $p = 0.004$ ; F:  $b = -1.149$ ,  $p = 0.043$ ; EM:  $b = -1.659$ ,  $p = 0.018$ ). Before adjustment for fiber intake, higher isobutyrate was predictive of poorer EF (EF:  $b = 0.017$ ,  $p = 0.015$ ; ISC:  $b = 0.014$ ,  $p = 0.036$ ; EM:  $b = 0.018$ ,  $p = 0.018$ ). Adjustment for fiber intake nullified the association with ISC and attenuated associations with EF and EM.

**Conclusions:** A western-style diet pattern and microbial-derived isobutyrate may have negative implications for EF in toddlers. Additionally, dietary fiber has the potential to influence these relationships.

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