Effects of Animal Source Food Supplementation on Neurocognitive Outcomes of HIV-Affected Kenyan School-Aged Children: A Randomized, Double-Blind, Controlled Intervention Trial

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Background

• Mothers with HIV and their offspring, HIV-positive and HIV-negative, are susceptible to the effects of malnutrition and infection

• Many families live in impoverished areas of the world where food insecurity, poor dietary quality, opportunistic infections, lethargy and encephalopathy, and lack of medical care can impact caregiver & child health

  • Which impacts caregivers’ abilities to cope and attend to the child’s developmental care

• Infants and young children born to HIV-positive mothers in resource-poor settings have demonstrated greater neurodevelopmental delays

• Nutritional interventions addressing diet quality (with animal source foods or soy) may address gaps in the diet and affect cognitive function

Objective

- Assess the effects of animal source food (ASF) versus soy versus wheat biscuit supplementation on the neurocognitive performance of HIV-affected, nutritionally at-risk school-aged children in rural Kenya
Methods: Study Location

Three rural communities near Eldoret in western Kenya
- Turbo,
- Mautuma,
- Soi

Image source: http://www.weather-forecast.com/locations/Eldoret
Methods

• Study Participants:
  • Sample of 49 school-aged children (4-8 years old) of HIV-positive drug-naïve women who received care at the Academic Model Providing Access to Healthcare (AMPATH) partnership clinics in western Kenya.
  • Some target children were found to be HIV-positive and receiving ART at baseline. The data from these children were excluded from the intervention effect analyses.
  • Participants enrolled over a two-year period (December 2008-December 2010).
Study Intervention

- Three-arm randomized, double-blind nutrition intervention trial
  - Isocaloric intervention biscuits made with either:
    - Dried powdered beef
    - Roasted soy flour
    - Wheat flour
  - Biscuits consumed at home via direct observation treatment (DOT), 5 days/week over 18 months
    - Follow-up at 6 months post intervention

(ERNST, et al. 2014)
Cognitive Assessments

- Performed at home every 6 months starting from the time children enrolled in study
  - Digit span forward,
  - Digit span backward,
  - Digit span total,
  - Raven’s Progressive Matrices (RPM), nonverbal test of cognitive performance, abstract reasoning and problem-solving (fluid intelligence),
  - Verbal meaning test,
  - Arithmetic test,
  - Embedded figure test,
  - Beery Test of Visual-Motor Integration (VMI), assesses integration of visual and motor abilities

(Beery and Beery 2010; Raven 1960; Sigman, Neumann et al. 1989; Weschler 1974)
## Results: Baseline Characteristics

<table>
<thead>
<tr>
<th></th>
<th>SOY (n=18)</th>
<th>BEEF (n=20)</th>
<th>WHEAT (n=11)</th>
<th>All (n=49)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbo</td>
<td>11 (61.1)</td>
<td>12 (60.0)</td>
<td>2 (18.2)</td>
<td>26 (51)</td>
<td>0.117</td>
</tr>
<tr>
<td>Soi</td>
<td>3 (16.7)</td>
<td>5 (25.0)</td>
<td>6 (54.6)</td>
<td>14 (29)</td>
<td></td>
</tr>
<tr>
<td>Mautuma</td>
<td>4 (22.2)</td>
<td>3 (15.0)</td>
<td>3 (27.3)</td>
<td>10 (20)</td>
<td></td>
</tr>
<tr>
<td><strong>Baseline Characteristics</strong></td>
<td>n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males*</td>
<td>8 (47)</td>
<td>10 (50)</td>
<td>3 (27.3)</td>
<td>21 (43.8)</td>
<td>0.448</td>
</tr>
<tr>
<td><strong>mean (sd)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline age (months)</td>
<td>73.2 (17.3)</td>
<td>68.4 (17.84)</td>
<td>62.7 (15.6)</td>
<td>68.9 (17.3)</td>
<td>0.289</td>
</tr>
<tr>
<td>CD4 count (cells/mm³)*</td>
<td>1046.3 (540.1)</td>
<td>950.9 (406.0)</td>
<td>1199.2 (467.0)</td>
<td>1041.5 (469.2)</td>
<td>0.378</td>
</tr>
<tr>
<td>HGB (g/dl)*</td>
<td>12.86 (0.9)</td>
<td>12.02 (1.4)</td>
<td>12.35 (1.3)</td>
<td>12.39 (1.2)</td>
<td>0.129</td>
</tr>
<tr>
<td>Weight (kg)*</td>
<td>18.1 (3.0)</td>
<td>17.1 (3.6)</td>
<td>15.5 (2.4)</td>
<td>17.0 (3.2)</td>
<td>0.124</td>
</tr>
<tr>
<td>Height (cm)*</td>
<td>110.7 (8.5)</td>
<td>106.0 (10.9)</td>
<td>105.2 (6.4)</td>
<td>107.4 (9.3)</td>
<td>0.219</td>
</tr>
<tr>
<td>BMI (kg/m²)*</td>
<td>14.7 (1.3)</td>
<td>15.0 (1.2)</td>
<td>14.0 (1.1)</td>
<td>14.6 (1.3)</td>
<td>0.100</td>
</tr>
<tr>
<td>Head circumference (cm)*</td>
<td>49.9 (1.7)</td>
<td>51.0 (2.2)</td>
<td>49.1 (1.2)</td>
<td>50.1 (1.9)</td>
<td>0.117</td>
</tr>
</tbody>
</table>

*Missing data occurred in 2% of gender; in 4% of CD4 counts, and HGB; in 6% of weight, height and BMI measures; and in 53% of head circumference measures.*
## Baseline Cognitive Scores

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>SOY (n=18)</th>
<th>BEEF (n=20)</th>
<th>WHEAT (n=11)</th>
<th>All (n=49)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital span Forward</td>
<td>3.44 (1.2)</td>
<td>3.05 (1.8)</td>
<td>2.63 (1.3)</td>
<td>3.10 (1.5)</td>
<td>0.366</td>
</tr>
<tr>
<td>Digital span Backward</td>
<td>1.33 (1.4)</td>
<td>0.85 (1.4)</td>
<td>0.45 (0.8)</td>
<td>0.94 (1.3)</td>
<td>0.212</td>
</tr>
<tr>
<td>Digital span total</td>
<td>4.78 (2.3)</td>
<td>3.90 (2.9)</td>
<td>3.09 (1.6)</td>
<td>4.04 (2.5)</td>
<td>0.196</td>
</tr>
<tr>
<td>Raven's progressive matrix (RPM) total</td>
<td>13.6 (2.9)</td>
<td>13.6 (3.4)</td>
<td>12.9 (5.4)</td>
<td>13.4 (3.7)</td>
<td>0.867</td>
</tr>
<tr>
<td>Verbal meaning total</td>
<td>26.2 (6.2)</td>
<td>25.1 (6.1)</td>
<td>19.9 (8.1)</td>
<td>23.3 (6.9)</td>
<td>0.046</td>
</tr>
<tr>
<td>Arithmetic total</td>
<td>4.67 (2.9)</td>
<td>4.20 (3.0)</td>
<td>2.63 (2.4)</td>
<td>4.02 (2.9)</td>
<td>0.174</td>
</tr>
<tr>
<td>Embedded figure test total</td>
<td>9.50 (1.9)</td>
<td>9.15 (2.4)</td>
<td>8.00 (3.3)</td>
<td>9.02 (2.5)</td>
<td>0.269</td>
</tr>
<tr>
<td>Beery VMI total</td>
<td>7.44 (3.5)</td>
<td>6.70 (2.6)</td>
<td>5.81 (2.7)</td>
<td>6.78 (3.0)</td>
<td>0.368</td>
</tr>
</tbody>
</table>
Intervention Results

- All 3 groups: significant increases in the outcomes’ scores over time (as expected through developmental maturation).

- Significant differences in rates of increase over time among all three groups for Raven’s Progressive Matrices (RPM) performance
  
  - For RPM total score, there were significant differences in rates of increase over time (F test df=2, $p<0.05$)
    
    - Scores of children in Soy group almost two times higher than those in Beef and Wheat groups ($p=0.012$)
    
    - No significant difference in RPM scores between Beef and Wheat groups ($p=0.849$)
Intervention Results, continued

- No significant difference between biscuit groups over time for:
  - Verbal meaning,
  - Digit Span Backward, Forward and Total,
  - Embedded figure test,
  - Arithmetic test
  - Beery Visual Motor Integration scores
Discussion & Conclusions

- Soy nutrients may enhance neurocognitive skills in HIV-affected school-aged children.
  - Evidence exists that flavonoids in soy may enhance human memory and neurocognitive performance by protecting and enhancing neuronal function and stimulating neurogenesis.

- Cognitive effects may also be mediated by family members’:
  - Nutritional status
  - Developmental stimulation and educational support

- In this randomized feeding trial school-aged children provided with soy protein supplementation showed greater improvement in non-verbal cognitive (fluid intelligence) performance compared to peers receiving isocaloric beef or wheat biscuits.

  (Spencer 2008)
References


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