Diet and Autism Spectrum Disorders

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Disclosures:

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Consulting:  GLG

......And I have bribed my own children to eat vegetables.
YOU ARE WHAT YOU EAT

By VICTOR H. LINDLAHR

HOW TO WIN AND KEEP HEALTH WITH DIET

REDUCING ... Learn how to lose weight quickly by eating the right kind of food.

THE MIDDLE YEARS ... A balanced diet can help ease you through those "middle years".

RHUMATISM—ARTHITIS ... A high Vitamin C diet helps bring relief from these painful symptoms.

VITAMINS—MINERALS ... Learn how to get health-giving vitamins and minerals from the foods you eat.

INDigestion—HEARTBURN ... Learn which foods to eat and which to avoid to prevent annoying troubles.

87 FOOD CHARTS AND TABLES ... How to select fruits and vegetables; how to prepare them appetizingly and economically for the maximum in health benefit.

Let America's Foremost Authority on Diet Show You How to Eat for Your Health's Sake!

Promote EU NEW EDITION

50c
If my children were what they ate, they would be:

A. Chicken Nuggets
B. Cheese Crackers
C. Chips
D. Pretzels
E. Air
Objectives:

1. Food Selectivity and ASD: Whys and Wherefores
2. Food selectivity and ASD: What are the nutritional implications?
3. What is the relationship of nutrition and behavior (with relevance to ASD)?
4. What is the evidence for dietary treatments for symptoms of ASD?
Mealtime Challenges are Common with ASD

- Food Selectivity and eating problems are reported in up to 46-89% of children with ASD
  - Food Selectivity and refusal, Disruptive Mealtime behaviors
  - Food selectivity is observed in toddlers prior to the diagnosis of ASD
    - Slow feeders by 6 m,
    - Picky eating by 15 m (Avon Longitudinal study, 2010)
- Food Selectivity persists through adolescence
Note: Picky Eating is Common in Children with Typical Development, too

Less than 1/3 of all children 3 to 7 yrs of age are NEVER perceived as picky eaters (Carruth and Skinner, 2000)

However, children with ASD are more likely to have eaten fewer than 50 foods in the past year (Tanner et al, 2015)

Children with ASD are more likely to be selective on the basis of texture, taste/smell, food mixture, shape but similar to other children on selectivity related to temperature, food touching, color (Hubbard et al, 2014)
wherefore /ˈ(h)werˌfôr/ adverb 1. for what reason:

Food Selectivity (limited variety of intake)
- Perseverative interests/obsessions:
  - texture, temperature, color, brand
- True Sensory differences impact taste and/or smell of food
- Routines
  - Presentation, packaging
- Food neophilia, anxiety with new or specific foods

Food Refusal
- Oppositional behaviors
- Disruptive mealtime behaviors
Sensory Differences?

People with ASD may be sensitive to variation in taste or flavor perception
  • Perseveration vs. sensory sensitivity?
  • Genetic predisposition: eg. TAS2R38 and PROP/PTC to sense bitter taste

On the Brief Mealtime Behavior Inventory (BAMBI), increased scores were associated with:
  • Increased reported sensory differences on Sensory Profile
  • Increased rate of other repetitive behaviors on the Repetitive Behavior Scale, Revised
  • AND decreased scores on the Healthy Eating Index

*Johnson et al 2014*
DSM5 Avoidant Restrictive Feeding Disorder

• A. Persistent failure to meet nutritional/energy needs with 1 (or more) of the following
  – Weight loss, failure to maintain weight (fall off growth chart)
  – Nutritional deficiency (significant)
  – Depends on enteral feedings or oral supplements
  – Marked interference with social functioning

• B. Not due to lack of food or cultural practice

• C. Does not occur with Anorexia Nervosa or Bulimia Nervosa (no body image issues)

• D. Not due to concurrent medical condition or mental health disorder
  – Unless, severity of feeding concerns exceeds what is typically seen with that condition
  – Warrants additional clinical attention
Addressing Food Selectivity:

Consistent meal time expectations

Repetition, repetition, repetition

Attention to sensory aspects of mealtimes
  – Quiet environment
  – Texture, taste and smell of food

Model mealtime behavior
  • Teachers, parents, peers

Food selectivity and ASD: What are the nutritional implications?
Dietary intakes in comparison to recommended intake levels or limits

**FIGURE 5-1. How Do Typical American Diets Compare to Recommended Intake Levels or Limits?**

**Eat more of these:**
- Whole grains: 15% vs. goal of 59%
- Vegetables: 42% vs. 52%
- Fruits: 44% vs. 61%
- Dairy: 44% vs. 61%
- Seafood: 75%
- Oils: 75%
- Fiber: 40% vs. 56%
- Potassium: 28% vs. 56%
- Vitamin D: 28% vs. 75%
- Calcium: 28%

**Eat less of these:**
- Calories from SoFAS*: 280% vs. limit of 200%
- Refined grains: 149% vs. 200%
- Sodium: 110% vs. 200%
- Saturated fat: 110% vs. 200%

SoFAS=Solid Fats, Added Sugars
Dietary Excess may Lead to Obesity in People with ASD

• Overweight and Obesity are increased in children AND ADULTS with ASD relative to the general population
• This may be related to:
  • Food selectivity
  • Fewer opportunities for active leisure
  • Medication side effects
  • Genetic factors
## Portion Sizes by Age From www.HealthyChildren.org

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Servings per Day</th>
<th>Portion Size for Ages 1 to 3</th>
<th>Portion Size for Ages 4 to 6</th>
<th>Portion Size for Ages 7 to 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>2–3 servings</td>
<td>¼ cup cooked, frozen, or canned</td>
<td>½ piece fresh</td>
<td>½ cup 100% juice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ piece fresh</td>
<td>½ cup cooked, frozen, or canned</td>
<td>1 piece fresh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ cup 100% juice</td>
<td>½ cup cooked, frozen, or canned</td>
<td>½ cup 100% juice</td>
</tr>
<tr>
<td>Vegetables</td>
<td>2–3 servings</td>
<td>¼ cup cooked</td>
<td>¼ cup cooked</td>
<td>½ cup cooked</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ cup salad</td>
<td>½ cup salad</td>
<td>1 cup salad</td>
</tr>
<tr>
<td>Grains</td>
<td>6–11 servings</td>
<td>½ slice bread</td>
<td>½ slice bread</td>
<td>1 slice bread</td>
</tr>
<tr>
<td></td>
<td></td>
<td>¼ cup cooked cereal, rice, or pasta</td>
<td>½ cup cooked cereal, rice, or pasta</td>
<td>½ cup cooked cereal, rice, or pasta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ cup dry cereal</td>
<td>½ cup dry cereal</td>
<td>¾–1 cup dry cereal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2–3 crackers</td>
<td>3–4 crackers</td>
<td>4–5 crackers</td>
</tr>
<tr>
<td>Meats and other proteins</td>
<td>2 servings</td>
<td>1 ounce meat, fish, chicken, or tofu</td>
<td>1 ounce meat, fish, chicken, or tofu</td>
<td>2–3 ounces meat, fish, chicken, or tofu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>¼ cup cooked beans</td>
<td>½ cup cooked beans</td>
<td>½ cup cooked beans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ egg</td>
<td>1 egg</td>
<td>1 or 2 eggs</td>
</tr>
<tr>
<td>Dairy</td>
<td>2–3 servings</td>
<td>½ cup milk</td>
<td>½ cup milk</td>
<td>1 cup milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ ounce cheese</td>
<td>1 ounce cheese</td>
<td>1 ounce cheese</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ cup yogurt</td>
<td>½ cup yogurt</td>
<td>¾–1 cup yogurt</td>
</tr>
</tbody>
</table>

Risk for Deficiencies

• Sharp et al (2018): Children in a clinical treatment program
  • 2/3 omitted vegetables
  • 27% omitted fruit

• Risk for deficiency:
  • Vitamin D 97%
  • Fiber 91%
  • Vitamin E 83%
  • Calcium 71%

• Not associated with poor growth or obesity
Can chicken nuggets and cheese crackers be a balanced diet?

<table>
<thead>
<tr>
<th>Time</th>
<th>Food Item</th>
<th>Description of Food/Beverage</th>
<th>Amount</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:45a</td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>½ cup</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>ice water with ice</td>
<td>6 oz</td>
<td></td>
</tr>
<tr>
<td>7:10a</td>
<td>oatmeal</td>
<td>Quaker Instant Oatmeal – Peach</td>
<td>1</td>
<td>package</td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>with oatmeal</td>
<td>2 oz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Milk</td>
<td>Goat Milk</td>
<td>2 oz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vitamin D</td>
<td>Liquid D₃</td>
<td>28 Drops</td>
<td></td>
</tr>
<tr>
<td>8:00a</td>
<td>water</td>
<td>ice water with ice</td>
<td>3 oz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>½ cup</td>
<td></td>
</tr>
<tr>
<td>10:45a</td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>3/4 cup</td>
<td></td>
</tr>
<tr>
<td>11:45a</td>
<td>Chicken Nuggets</td>
<td>Markey Pantry (Target) Chicken Nuggets – Micro waved</td>
<td>4</td>
<td>Nuggets</td>
</tr>
<tr>
<td>1:00p</td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>½ cup</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>ice water with ice</td>
<td>6 oz</td>
<td></td>
</tr>
<tr>
<td>2:35p</td>
<td>applesauce</td>
<td>Motts Apple Sauce – individual cup – Calcium plus</td>
<td>1</td>
<td>Cup</td>
</tr>
<tr>
<td>2:40p</td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>½ cup</td>
<td></td>
</tr>
<tr>
<td>4:30p</td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>½ cup</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>water with ice</td>
<td>6 oz</td>
<td></td>
</tr>
<tr>
<td>5:10p</td>
<td>Chicken Nuggets</td>
<td>Mc Donald’s Chicken Nuggets</td>
<td>2</td>
<td>Nuggets</td>
</tr>
<tr>
<td>5:15p</td>
<td>Gold Fish</td>
<td>Pepperidge Farm Goldfish Cheddar</td>
<td>½ cup</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>water with ice</td>
<td>4 oz</td>
<td></td>
</tr>
</tbody>
</table>
### Selected Nutrient Report

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Units</th>
<th>RDA/2</th>
<th>Total Intake</th>
<th>Average Intake</th>
<th>RDA/2</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>mg</td>
<td>500</td>
<td>1558.14</td>
<td>12.58</td>
<td>103.8%</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>mg</td>
<td>7</td>
<td>44.46</td>
<td>6.33</td>
<td>211.8%</td>
<td></td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td>mg</td>
<td>15</td>
<td>58.63</td>
<td>7.88</td>
<td>130.3%</td>
<td></td>
</tr>
<tr>
<td>Total Vitamin A Activity</td>
<td>mcg</td>
<td>300</td>
<td>982.469</td>
<td>32.74</td>
<td>109.1%</td>
<td></td>
</tr>
<tr>
<td>Vitamin D (calciferol)</td>
<td>mcg</td>
<td>15</td>
<td>0.836</td>
<td>0.28</td>
<td>186.6%</td>
<td></td>
</tr>
<tr>
<td>Vitamin E (Total Alpha-Tocopherol)</td>
<td>mcg</td>
<td>0.9</td>
<td>2.163</td>
<td>0.72</td>
<td>60.1%</td>
<td></td>
</tr>
<tr>
<td>Vitamin B-12 (cobalamin)</td>
<td>mcg</td>
<td>0.5</td>
<td>7.034</td>
<td>2.34</td>
<td>408.93%</td>
<td></td>
</tr>
<tr>
<td>Riboflavin (vitamin B2)</td>
<td>mg</td>
<td>0.5</td>
<td>5.963</td>
<td>1.90</td>
<td>307.53%</td>
<td></td>
</tr>
<tr>
<td>Pantothenic Acid</td>
<td>mg</td>
<td>0.2</td>
<td>8.926</td>
<td>2.98</td>
<td>148.77%</td>
<td></td>
</tr>
<tr>
<td>Choline</td>
<td>mg</td>
<td>2.0</td>
<td>195.572</td>
<td>65.19</td>
<td>32.60%</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>mg</td>
<td>0.34</td>
<td>1.601</td>
<td>0.53</td>
<td>156.96%</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>mcg</td>
<td>1.2</td>
<td>6.625</td>
<td>2.28</td>
<td>109.5%</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>mg</td>
<td>450</td>
<td>1822.602</td>
<td>607.53</td>
<td>132.07%</td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>mcg</td>
<td>20</td>
<td>254.952</td>
<td>84.88</td>
<td>424.92%</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>mg</td>
<td>3</td>
<td>11.714</td>
<td>3.90</td>
<td>130.16%</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>mg</td>
<td>3000</td>
<td>2108.365</td>
<td>722.80</td>
<td>24.09%</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>mg</td>
<td>10000</td>
<td>7203.654</td>
<td>2401.22</td>
<td>160.03%</td>
<td></td>
</tr>
</tbody>
</table>

### Upper Limit Report

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Units</th>
<th>TUL</th>
<th>Total Intake</th>
<th>Average Intake</th>
<th>UL %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>mg</td>
<td>6.625</td>
<td>2.28</td>
<td>113.75%</td>
<td></td>
</tr>
<tr>
<td>Synthetic Pola</td>
<td>mcg</td>
<td>302.961</td>
<td>343.29</td>
<td>114.3%</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>mg</td>
<td>7203.654</td>
<td>2401.22</td>
<td>160.03%</td>
<td></td>
</tr>
</tbody>
</table>

### Deficient Nutrient Report

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Units</th>
<th>DRUI</th>
<th>Total Intake</th>
<th>Average Intake</th>
<th>DRUI %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>mg</td>
<td>3000.00</td>
<td>2108.365</td>
<td>722.80</td>
<td>24.09%</td>
</tr>
<tr>
<td>Vitamin D (calciferol)</td>
<td>mcg</td>
<td>15.00</td>
<td>0.936</td>
<td>0.29</td>
<td>105%</td>
</tr>
<tr>
<td>Choline</td>
<td>mg</td>
<td>200.00</td>
<td>195.572</td>
<td>65.19</td>
<td>32.60%</td>
</tr>
<tr>
<td>Total Dietary Fiber</td>
<td>g</td>
<td>19.00</td>
<td>33.495</td>
<td>11.17</td>
<td>58.79%</td>
</tr>
</tbody>
</table>
Reports of Nutritional Intake of Children with ASD Vary with Study Design and Population:

**Study Designs Differed**
- 3 Day recall, 7 Day recall, 24 recall, Food Frequency Record
- Analysis software
- Definition of sufficiency
  - RDA vs EAR

**Consistent findings include:**
- Low intake of Vitamin D, Calcium and Fiber, choline
- Adequate energy intake

**Compared to control groups:**
- Similar nutrition to siblings
- Less variety, associated with more deficiencies

**Studies differed in reports of:**
- Lower intake of Iron, Zinc, Vitamins C, A, B12, K, folic acid
- Higher intake of B6, Mg, protein
Compared to NHANES, Lower intake of:
- Potassium
- Fiber
- Vitamin D
- Vitamin E
- Calcium

Excess intake of:
- Sodium
- Vitamin A
- Zinc
- Manganese

Similar to other children in America (NHANES)

BMI - Children with ASD:
- **Ages 2-5** are more likely to be **obese** compared to NHANES data
- **Ages 6-11** are more likely to be **underweight** compared to NHANES data

Hyman, 2012
Definitions: Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies

- **Recommended Dietary Allowance (RDA):** Average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals.

- **Adequate Intake (AI):** Assumed to ensure nutritional adequacy; established when evidence is insufficient to develop an RDA.

- **Estimated Average Requirement (EAR):** Average daily level of intake estimated to meet the requirements of 50% of healthy individuals.

- **Tolerable Upper Intake Level (UL):** Maximum daily intake unlikely to cause adverse health effects.
% of individuals with **inadequate intake**

[Bar chart showing the percentage of individuals with inadequate intake of Calcium and Vitamin D across different age groups and gender categories.]
% of individuals with adequate intake

![Bar chart showing % of individuals with adequate intake for Potassium and Choline across different age groups and gender, with separate categories for non-supplement users (diet only), supplement users (diet only), and supplement users (diet + supplement).]
Severe Selectivity Can Lead to Deficiency Disorders:

- Vitamin D → Rickets
- Vitamin C → Scurvy
- Vitamin K → bleeding
- Vitamin A → Eye problems
- Iodine → Hypothyroid
### Top Food Sources of Specific Nutrients in the US

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin D</td>
<td>Fortified foods (dairy products), margarine; breakfast cereals, fatty fish; sunshine</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Citrus fruits, tomatoes and tomato juice, and potatoes; also red and green peppers, kiwifruit, broccoli, strawberries, Brussels sprouts, and cantaloupe; fortified foods</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Dairy products, liver, fish, fortified cereal; carrots, broccoli, cantaloupe, squash</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Spinach; broccoli; iceberg lettuce; and fats and oils (soybean and canola)</td>
</tr>
<tr>
<td>Iodine</td>
<td>Dairy and grain products, iodized salt, also seafood, seaweed, eggs</td>
</tr>
</tbody>
</table>
What is the relationship of nutrition and behavior (with relevance to ASD)?
Example 1: Iron Deficiency

**Iron deficiency**: Latif 2002; Dosman 2006, Reynolds 2012, Adequate intake, but more likely to have low ferritin, Tseng 2018 meta analysis suggests data inconclusive

- Dietary sources of heme iron: lean meat, seafood; nonheme iron: nuts, beans, vegetables, and fortified grain products, Wheat Flour is fortified with iron in the US
- Excess supplementation can lead to GI distress, decreased zinc absorption
- Iron is necessary for synthesis of Dopamine, serotonin
  - Deficiency in infancy may have long term effects
Studies done in children without ASD:

• Iron Deficiency in infancy and early childhood associated with:
  • Inattention/decreased inhibitory control
  • Lower IQ/school achievement/memory
  • Irritability
  • Psychomotor delays
  • Adolescent and adult anxiety/depression
  • Toddlers: increased hesitancy and wariness in novel situations

• May be associated with restless leg syndrome, night waking

Example 2: Vitamin D

**Bone Health:**

- Hediger ML et al (2008), cortical bone thickness less in boys 4-8 y with ASD, least with Casein Free diet
- Neumeyer AM et al (2013) bone mineral density (BMD) lower in boys with ASD 8-14
- Furlano RI, et al (2014) lower risk for fractures in boys with ASD (3-8 yrs)
- Barnhill (2017) Lower BMD not associated with intake, blood levels, or GI symptoms in boys 4-8 yrs
- Neumeyer (2018), Ca and Vitamin D levels similar in boys 8-17 yrs, lower BMD associated with lower intake of protein, levels of Ca or Phos, less activity
Vitamin D does other things….

- Case report of improvement in symptoms with Vitamin D supplementation in a preschool child in China (Jia, 2014)
- Saad et al (2018) RCT in 109 children (3-10 yrs)
  - Measures: ABC/CARS/SRS/ATEC
  - 4 m treatment
  - Reported improvement in irritability, stereotyped behavior (ABC), social awareness (SRS)
- Needs replication in other populations
References you can use on General Nutrition:

https://health.gov/dietaryguidelines/2015/guidelines/
https://www.choosemyplate.gov/
https://www.healthychildren.org/English/healthy-living/nutrition/Pages/Gluten-Free-Shopping-Tips-for-Parents.aspx
Nutrition Factoids:

• Breakfast improves attention
• MVIs are usually not needed
  • 2/3 of 292 Children with ASD participating in AS-ATN use Nutritional Supplements Compared to 1/3 in General Pediatric Population (NHANES) Stewart et al 2015
• Foods in the US may be highly fortified – an adequate diet may look different than a balanced diet
Do Dietary Interventions Affect Behavior in ASD?

- GI symptoms commonly reported
- Food selectivity
- Observations around elimination diets and behavior

Explanations for Empiric Observations-Require Research Support:
- Opioid Hypothesis
- Leaky Gut
- Immunologic Dysregulation
- Alteration of Microbiome
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Bias</th>
<th>Outcome</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghalichi, 2016</td>
<td>N=80</td>
<td>high</td>
<td>GF improved bloating, stomachache, constipation; stereotypies and constipation</td>
<td>GARS2 for behavioral outcome data</td>
</tr>
<tr>
<td>Hyman, 2016</td>
<td>N=14 Challenge</td>
<td>Low/moderate</td>
<td>No difference in sleep, stool, behavior</td>
<td>Controlled for ABA</td>
</tr>
<tr>
<td>Pederson, 2014</td>
<td>Reanalysis</td>
<td>high</td>
<td>Most likely to respond are 7-9 Yrs with ADHD sm</td>
<td>Whitely, 2010</td>
</tr>
<tr>
<td>Pennisi &amp; Klein 2012</td>
<td>387</td>
<td>high</td>
<td>Parents report more effective with GI sm, food allergy or sensitivity</td>
<td>Reported improved social sm</td>
</tr>
<tr>
<td>Johnson, 2011</td>
<td>N=22, 3 m</td>
<td>moderate</td>
<td>No change, parallel group single blind RCT, CBCL, direct observe</td>
<td></td>
</tr>
<tr>
<td>Whitely, 2010</td>
<td>N=72, 12m</td>
<td>high</td>
<td>ASD sm improved at 12 but not 24 months</td>
<td>Single blind, did not account for attrition</td>
</tr>
<tr>
<td>Elder, 2006, 2007</td>
<td>N= 15</td>
<td>moderate</td>
<td>No difference in symptom severity or language</td>
<td>7/15 better language, not substantiated</td>
</tr>
<tr>
<td>Knivsberg, 2002,2003</td>
<td>N=10, 12 m</td>
<td>high</td>
<td>Improvement in cognition, language, social,</td>
<td>Over 1 year</td>
</tr>
</tbody>
</table>
Effect of Gluten Free Casein Free Diet on Nutrient Inadequacies for Select Nutrients in Children with Autism Spectrum Disorders

Figure 3

- ** = p < 0.01
- * = p < 0.05
- *** = p < 0.001
Nutritional Impact of GFCF Diet:

• Mari-Bauset (2017) : 20 GFCF, 85 Mediterranean Diet
  • GFCF: lower BMI, lower intake of panthothenic acid, Ca, Phos, Na
  • GFCF: higher intake of fiber
  • Needed Vitamin D supplementation

• Cultural variation in diet
What About Other Dietary Interventions?

• Modified Adkins Diet vs GFCF vs typical diet (El Rashidy et al 2018)
  • MAD 60% calories from fat, 30% protein, 10% carb
  • Participants 3-8 yrs, behavior therapy 2 x week
  • ATEC and CARS, both improved compared to typical diet, MAD>GFCF for cognitive and socialization by report
  • 5/15 MAD dropped out

• Modified ketogenic diet with MCT oil, open trial (Lee, RWY et al 2018)
  • Participants 2-17 yrs x 3 m(15), x6 m (10), 10/15 also ADHD
  • Observers unaware of treatment condition
  • ADOS improvement, not in repetitive behaviors: CARS improved in imitation, body use, fear/nervousness
  • Limitations: 15/46 counseled were able to do study, 19% diarrhea/vomiting/fatigue
Do Food Additives Affect Behavior (ADHD)?

Feingold (1975):
- Allergy hypothesis
- Elimination of artificial flavors, preservatives, artificial sweeteners, natural salicylates

Oligoantigenic Diet
There is little evidence to support the use of nutritional supplements or dietary therapies for children with ASD.

Why is it Difficult to Study the Effects of Dietary Interventions?

- Autism is not a single disorder
- Small study samples
- Length of dietary treatment
- Impact of other interventions
- Which outcome is the outcome related to diet?

If you think research is expensive, try disease.

Mary Lasker
How Might Dietary Change Affect Behavior?

Low iron stores

Restless leg syndrome and night waking?

Inattention? Irritability?

Decreased consumption of Omega 3 fatty acids

• Inattention?

Artificial Food Coloring/preservatives

• Inattention?
Despite the Absence of Supporting Evidence Dietary Interventions are Popular:

- Alignment with personal and societal views about health and wellness
- Seen as having fewer side effects than prescription medicines
- Can be decided upon and managed by the family
- The evidence base for many “conventional therapies” is modest.
Conclusions:

• **You are what you eat**: Be aware of sound nutritional practices
  - Families using restricted diets should consider RD consultation
  - Use scientific evidence for decision making about therapies
  - Increase variety in foods using behavioral strategies

• **Do ask, do tell**: Provide clinicians a history of diet + supplements

• **Review the data supporting – and refuting – nutritional interventions**: Nutrition (too much and too little) may affect behavior and overall health in children with and without ASD
You are what you eat!(at least at some level)
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