Diet and Autism Spectrum Disorders

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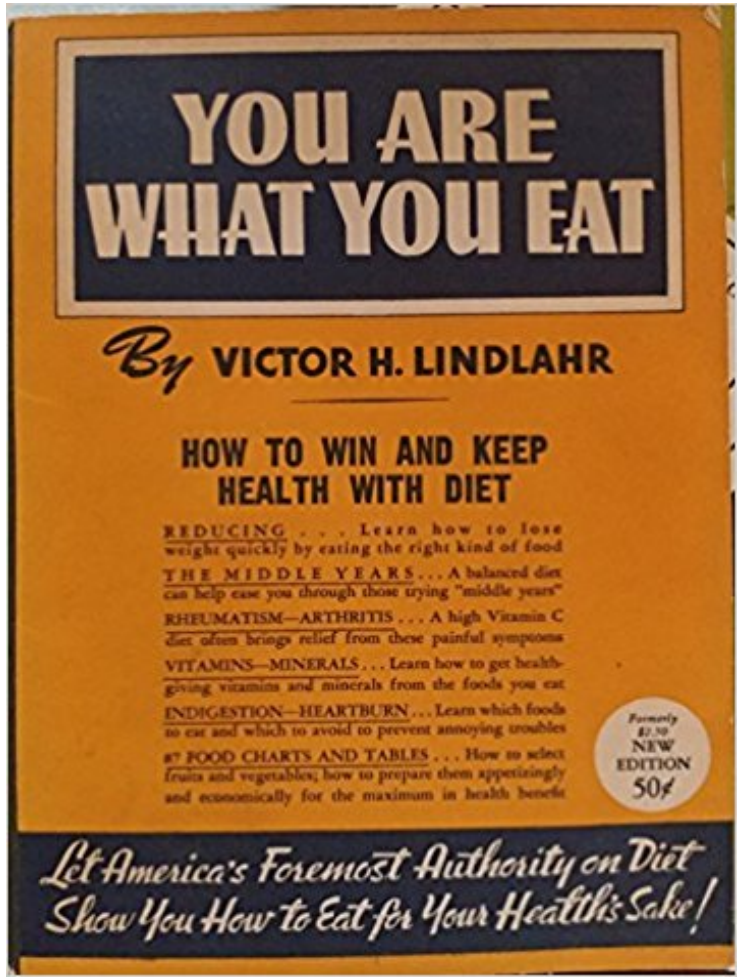
……And I have bribed my own children to eat vegetables.


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 trying "middle years"
RHEUMATISM—ARTHRITIS . . . A high Vitamin C diet often brings 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
FOOD CHARTS AND TABLES . . . How to select fruits and vegetables; how to prepare them appetizingly and economically for the maximum in health benefit
Formerly $1.50
NEW EDITION
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Let America's Foremost Authority on Diet Show You How to Eat for Your Health's Sake!

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

A. Chicken Nuggets

B. Cheese Crackers

C. Chips

D. Pretzels

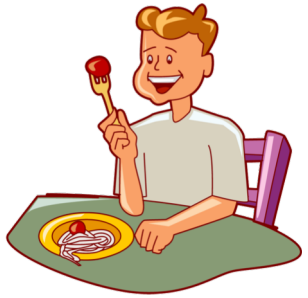
E. Air

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



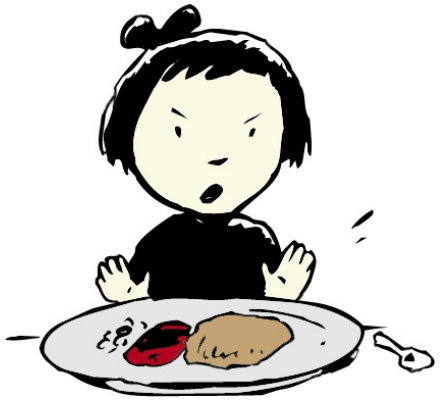
Note: Picky Eating is Common in Children with Typical Development, too

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)

where·fore /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 neophobia, anxiety with new or specific foods

Food Refusal

- Oppositional behaviors
- Disruptive mealtime behaviors

Sensory Differences?

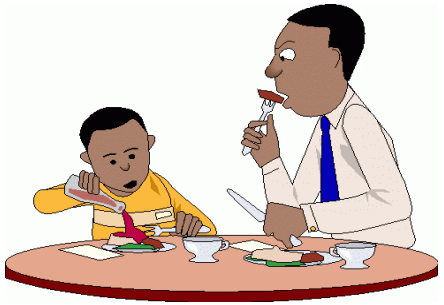
People with ASD may be sensitive to variation in taste or flavor perception

- 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:

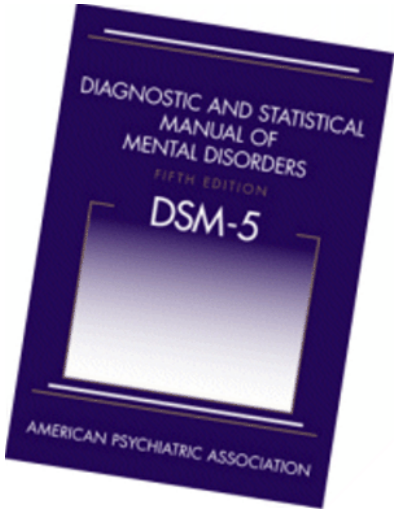
- Increased reported sensory differences on Sensory Profile
- Increased rate of other repetitive behaviors on the Repetitive Behavior Scale, Revised
- AND decreased scores on the Healthy Eating Index

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

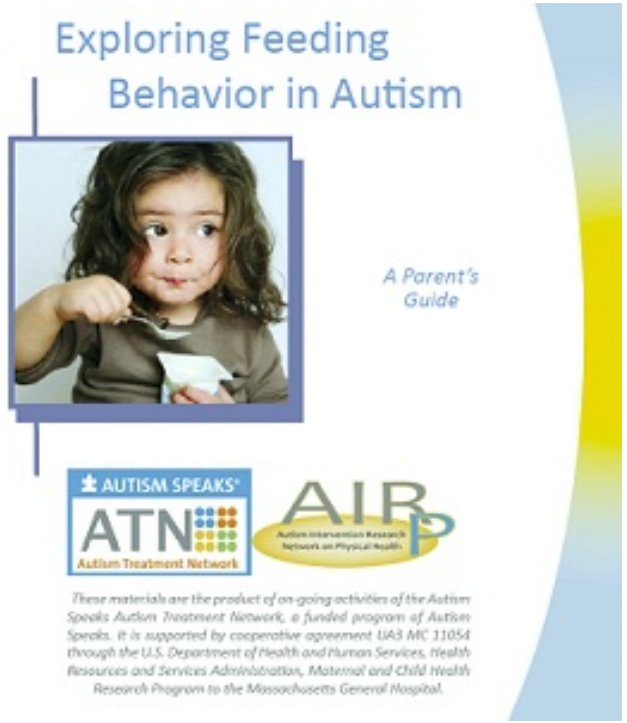
Repetition, repetition, repetition

Attention to sensory aspects of mealtimes

- Quiet environment
- Texture, taste and smell of food

Model mealtime behavior

- Teachers, parents, peers

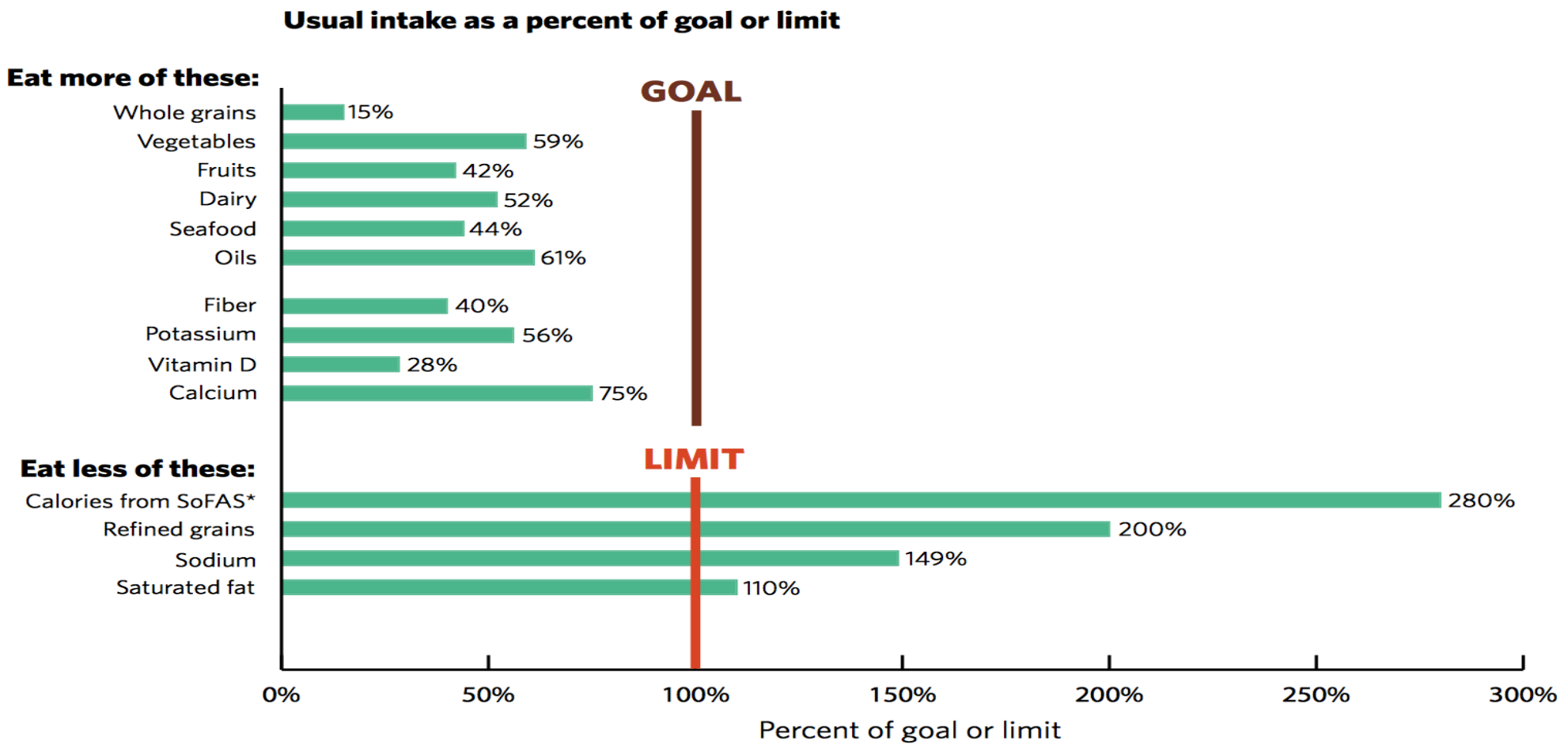


https://www.autismspeaks.org/science/find-resources-programs/autism-treatment-network/tools-you-can-use/atn-air-p-guide-exploring-feeding-behavior

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?



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

Food Group	Servings per Day	Portion Size for Ages 1 to 3	Portion Size for Ages 4 to 6	Portion Size for Ages 7 to 10
Fruits	2–3 servings	¼ cup cooked, frozen, or canned ½ piece fresh ¼ cup 100% juice	¼ cup cooked, frozen, or canned ½ piece fresh ⅓ cup 100% juice	⅓ cup cooked, frozen, or canned 1 piece fresh ½ cup 100% juice
Vegetables	2–3 servings	¼ cup cooked	¼ cup cooked ½ cup salad	½ cup cooked 1 cup salad
Grains	6–11 servings	½ slice bread ¼ cup cooked cereal, rice, or pasta ⅓ cup dry cereal 2–3 crackers	½ slice bread ⅓ cup cooked cereal, rice, or pasta ½ cup dry cereal 3–4 crackers	1 slice bread ½ cup cooked cereal, rice, or pasta ¾–1 cup dry cereal 4–5 crackers
Meats and other proteins	2 servings	1 ounce meat, fish, chicken, or tofu ¼ cup cooked beans ½ egg	1 ounce meat, fish, chicken, or tofu ⅓ cup cooked beans 1 egg	2–3 ounces meat, fish, chicken, or tofu ½ cup cooked beans 1 or 2 eggs
Dairy	2–3 servings	½ cup milk ½ ounce cheese ⅓ cup yogurt	½ cup milk 1 ounce cheese ½ cup yogurt	1 cup milk 1 ounce cheese ¾–1 cup yogurt

Adapted from Dietz WH, Stern L, eds. *Nutrition: What Every Parent Needs to Know.* 2nd ed. Elk Grove Village, IL: American Academy of Pediatrics; 2012:194.

Risk for Deficiencies

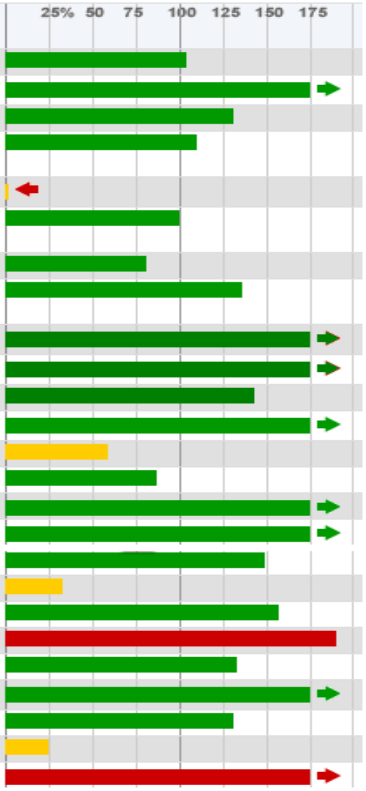
- Sharp et al (2018): Children in a clinical treatment program
  - 2/3 omitted vegetables
  - 27% omitted fruit
- Risk for deficiency:
  - Vitamin D 97%
  - Fiber 91%
  - Vitamin E 83%
  - Calcium 71%
- Not associated with poor growth or obesity

Can chicken nuggets and cheese crackers be a balanced diet?

Time*	Food Item	Description of Food/Beverage	Amount	Unit
6:45a	Gold Fish	Pepperidge Farm Goldfish Cheddar	½	cup
	water	ice water with ice	6	oz
7:10a	oatmeal	Quaker Instant Oatmeal – Peach	1	package
	water	with oatmeal	2	oz
	Milk	Goat Milk	2	oz
	Vitamin D	Liquid D_3	28	Drops
8:00a	water	ice water with ice	3	oz
	Gold Fish	Pepperidge Farm Goldfish Cheddar	½	cup
10:45a	Gold Fish	Pepperidge Farm Goldfish Cheddar	3/4	cup
11:45a	Chicken Nuggets	Markey Pantry (Target) Chicken Nuggets – Micro waved	4	Nuggets
1:00p	Gold Fish	Pepperidge Farm Goldfish Cheddar	½	cup
	water	ice water with ice	6	oz
2:35p	applesauce	Motts Apple Sauce – individual cup – Calcium plus	1	Cup
2:40p	Gold Fish	Pepperidge Farm Goldfish Cheddar	½	cup
4:30p	Gold Fish	Pepperidge Farm Goldfish Cheddar	½	cup
	water	water with ice	6	oz
5:10p	Chicken Nuggets	McDonald's Chicken Nuggets	2	Nuggets
5:15p	Gold Fish	Pepperidge Farm Goldfish Cheddar	½	cup
6:40p	water	water with ice	4	oz

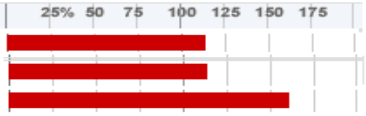
Selected Nutrient Report

Nutrient	Units	RDA/AI	Total Intake	Average Intake	RDA/AI %
Calcium	mg	500	1558.14	519.38	103.88%
Iron	mg	7	44.485	14.83	211.83%
Vitamin C (ascorbic acid)	mg	15	58.633	19.54	130.30%
Total Vitamin A Activity (Retinol Activity Equivalents)	mcg	300	982.459	327.49	109.16%
Vitamin D (calciferol)	mcg	15	0.836	0.28	1.86%
Vitamin E (Total Alpha-Tocopherol)	mg	6	17.872	5.96	99.29%
Vitamin B-12 (cobalamin)	mcg	0.9	2.163	0.72	80.11%
Vitamin B-6 (pyridoxine, pyridoxyl, pyridoxamine)	mg	0.5	2.027	0.68	135.13%
Niacin Equivalents	mg	6	86.194	28.73	478.86%
Dietary Folate Equivalents	mcg	150	2224.33	741.44	494.30%
Magnesium	mg	80	342.584	114.19	142.74%
Total Protein	g	13	121.146	40.38	310.63%
Total Dietary Fiber	g	19	33.495	11.17	58.76%
Vitamin K (phylloquinone)	mcg	30	77.887	25.96	86.54%
Thiamin (vitamin B1)	mg	0.5	7.034	2.34	468.93%
Riboflavin (vitamin B2)	mg	0.5	5.963	1.99	397.53%
Pantothenic Acid	mg	2	8.926	2.98	148.77%
Choline		200	195.572	65.19	32.60%
Copper	mg	0.34	1.601	0.53	156.96%
Manganese	mg	1.2	6.825	2.28	189.58%
Phosphorus	mg	460	1822.602	607.53	132.07%
Selenium	mcg	20	254.952	84.98	424.92%
Zinc	mg	3	11.714	3.90	130.16%
Potassium	mg	3000	2168.385	722.80	24.09%
Sodium	mg	1000	7203.654	2,401.22	240.12%



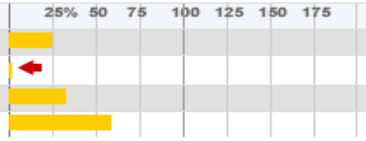
Upper Limit Report

Nutrient	Units	TUL	Total Intake	Average Intake	UL %
Manganese	mg	2	6.825	2.28	113.75%
Synthetic Folate	mcg	300	1029.861	343.29	114.3%
Sodium	mg	1500	7203.654	2,401.22	160.08%



Deficient Nutrient Report

Nutrient	Units	DRI/AI	Total Intake	Average Intake	DRI/AI %
Potassium	mg	3,000.00	2168.385	722.80	24.09%
Vitamin D (calciferol)	mcg	15.00	0.836	0.28	1.86%
Choline		200.00	195.572	65.19	32.60%
Total Dietary Fiber	g	19.00	33.495	11.17	58.76%



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

Diet and Nutrition in ASD: ATN Study Summary

Autism Treatment Network

AIRP Autism Intervention Research Network on Physical Health

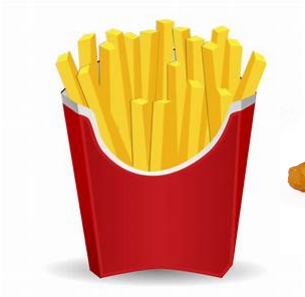
(n=292)

Compared to NHANES, Lower intake of:

- Potassium
- Fiber
- Vitamin D
- Vitamin E
- Calcium

Excess intake of:

- Sodium
- Vitamin A
- Zinc
- Manganese



Ages 1-3

Similar to other children in America (NHANES)

BMI - Children with ASD:

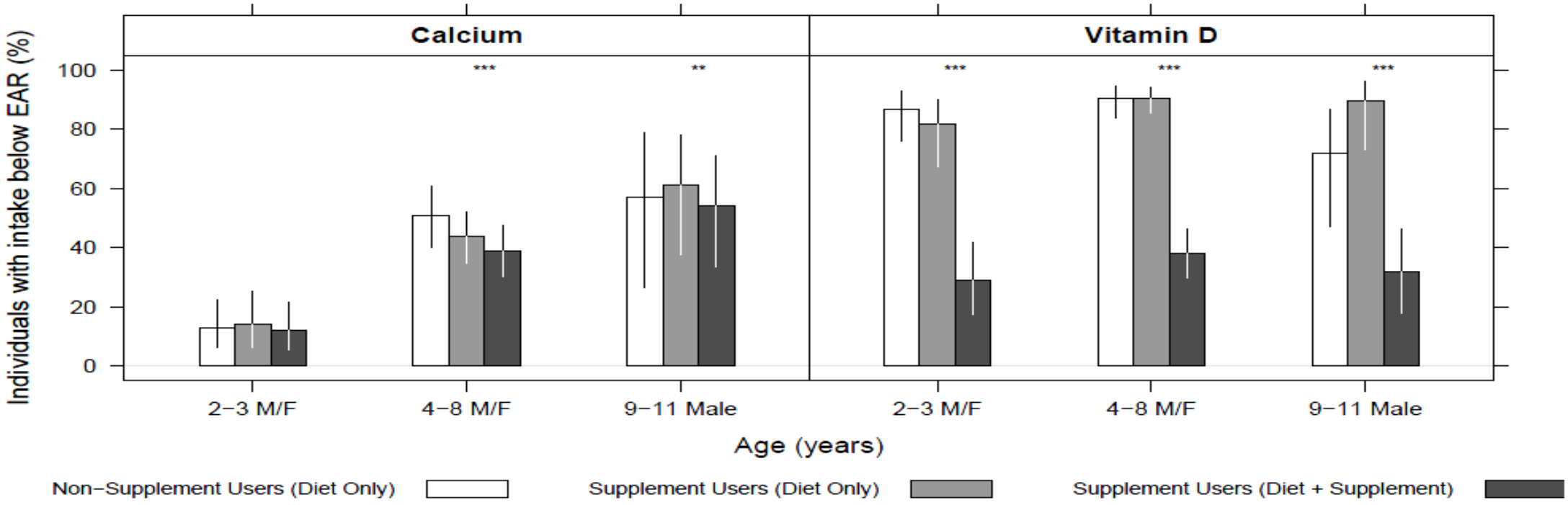
- **ages 2-5** are more likely to be **obese** compared to NHANES data
- **ages 6-11** are more likely to be **underweight** compared to NHANES data

Hyman, 2012

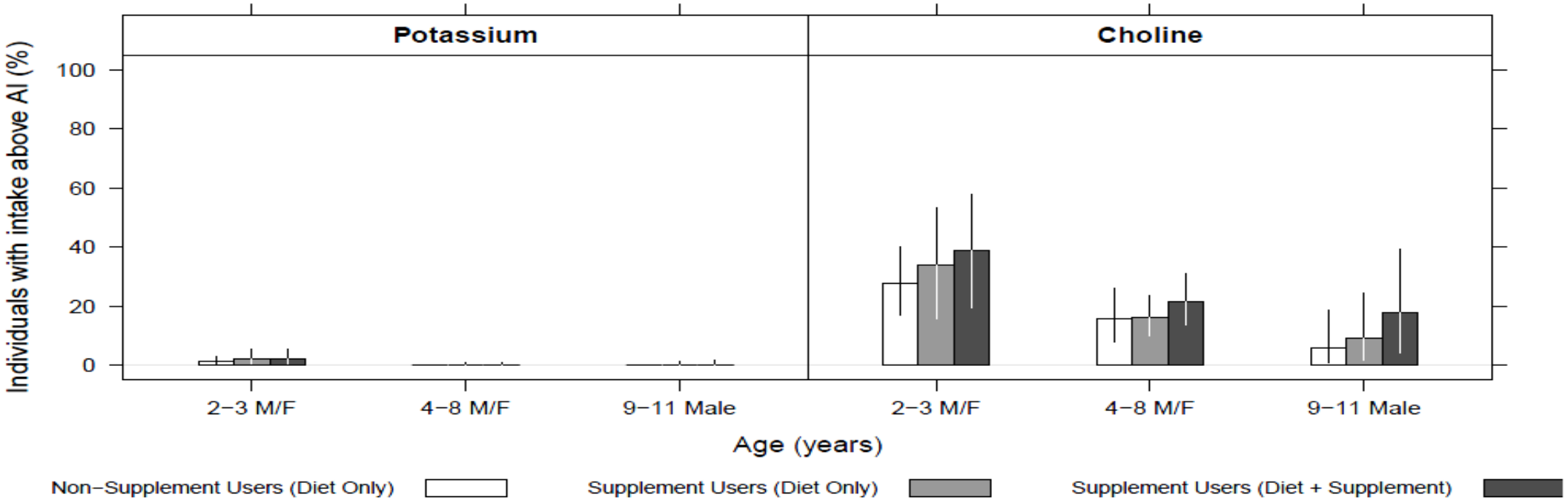
Definitions: Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies

- 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



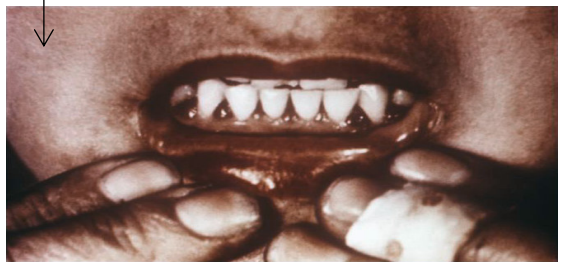
% of individuals with adequate intake



Severe Selectivity Can Lead to Deficiency Disorders:

Vitamin D→Rickets

Vitamin C→ Scurvy

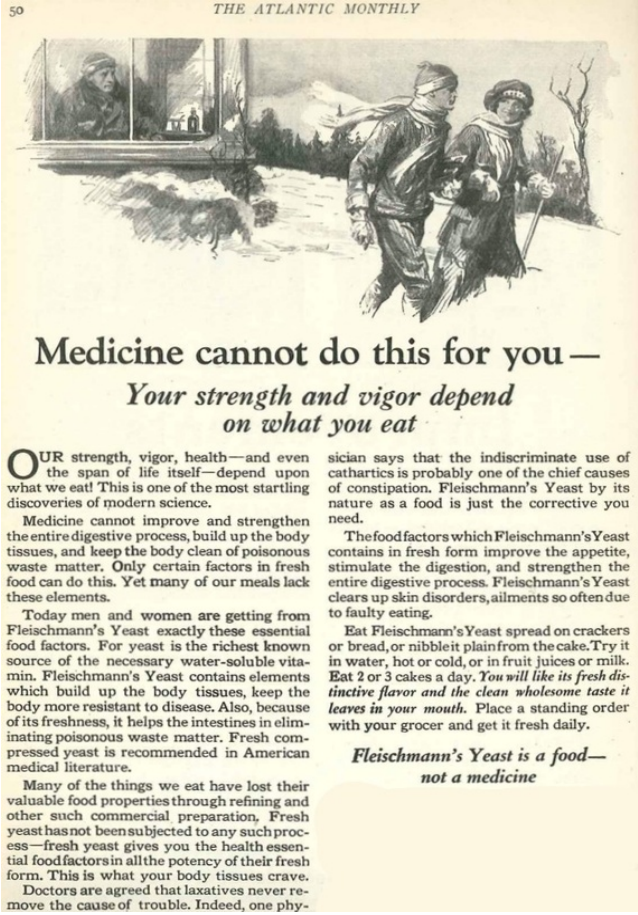


Vitamin K→bleeding
Vitamin A→Eye problems
Iodine →Hypothyroid

Top Food Sources of Specific Nutrients in the US

Nutrient	Food Sources
Vitamin D	Fortified foods (dairy products), margarine; breakfast cereals, fatty fish; sunshine
Vitamin C	Citrus fruits, tomatoes and tomato juice, and potatoes; also red and green peppers, kiwifruit, broccoli, strawberries, Brussels sprouts, and cantaloupe; fortified foods
Vitamin A	Dairy products, liver, fish, fortified cereal; carrots, broccoli, cantaloupe, squash
Vitamin K	Spinach; broccoli; iceberg lettuce; and fats and oils (soybean and canola)
Iodine	Dairy and grain products, iodized salt, also seafood, seaweed, eggs

What is the relationship of nutrition and behavior (with relevance to ASD)?



50 THE ATLANTIC MONTHLY

Medicine cannot do this for you—

Your strength and vigor depend on what you eat

OUR strength, vigor, health—and even the span of life itself—depend upon what we eat! This is one of the most startling discoveries of modern science.

Medicine cannot improve and strengthen the entire digestive process, build up the body tissues, and keep the body clean of poisonous waste matter. Only certain factors in fresh food can do this. Yet many of our meals lack these elements.

Today men and women are getting from Fleischmann's Yeast exactly these essential food factors. For yeast is the richest known source of the necessary water-soluble vitamin. Fleischmann's Yeast contains elements which build up the body tissues, keep the body more resistant to disease. Also, because of its freshness, it helps the intestines in eliminating poisonous waste matter. Fresh compressed yeast is recommended in American medical literature.

Many of the things we eat have lost their valuable food properties through refining and other such commercial preparation. Fresh yeast has not been subjected to any such process—fresh yeast gives you the health essential food factors in all the potency of their fresh form. This is what your body tissues crave.

Doctors are agreed that laxatives never remove the cause of trouble. Indeed, one physician says that the indiscriminate use of cathartics is probably one of the chief causes of constipation. Fleischmann's Yeast by its nature as a food is just the corrective you need.

The food factors which Fleischmann's Yeast contains in fresh form improve the appetite, stimulate the digestion, and strengthen the entire digestive process. Fleischmann's Yeast clears up skin disorders, ailments so often due to faulty eating.

Eat Fleischmann's Yeast spread on crackers or bread, or nibble it plain from the cake. Try it in water, hot or cold, or in fruit juices or milk. Eat 2 or 3 cakes a day. *You will like its fresh distinctive flavor and the clean wholesome taste it leaves in your mouth.* Place a standing order with your grocer and get it fresh daily.

Fleischmann's Yeast is a food—not a medicine

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

Doom, JR and Georgioff (2014)
Current Pediatr Rep

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:

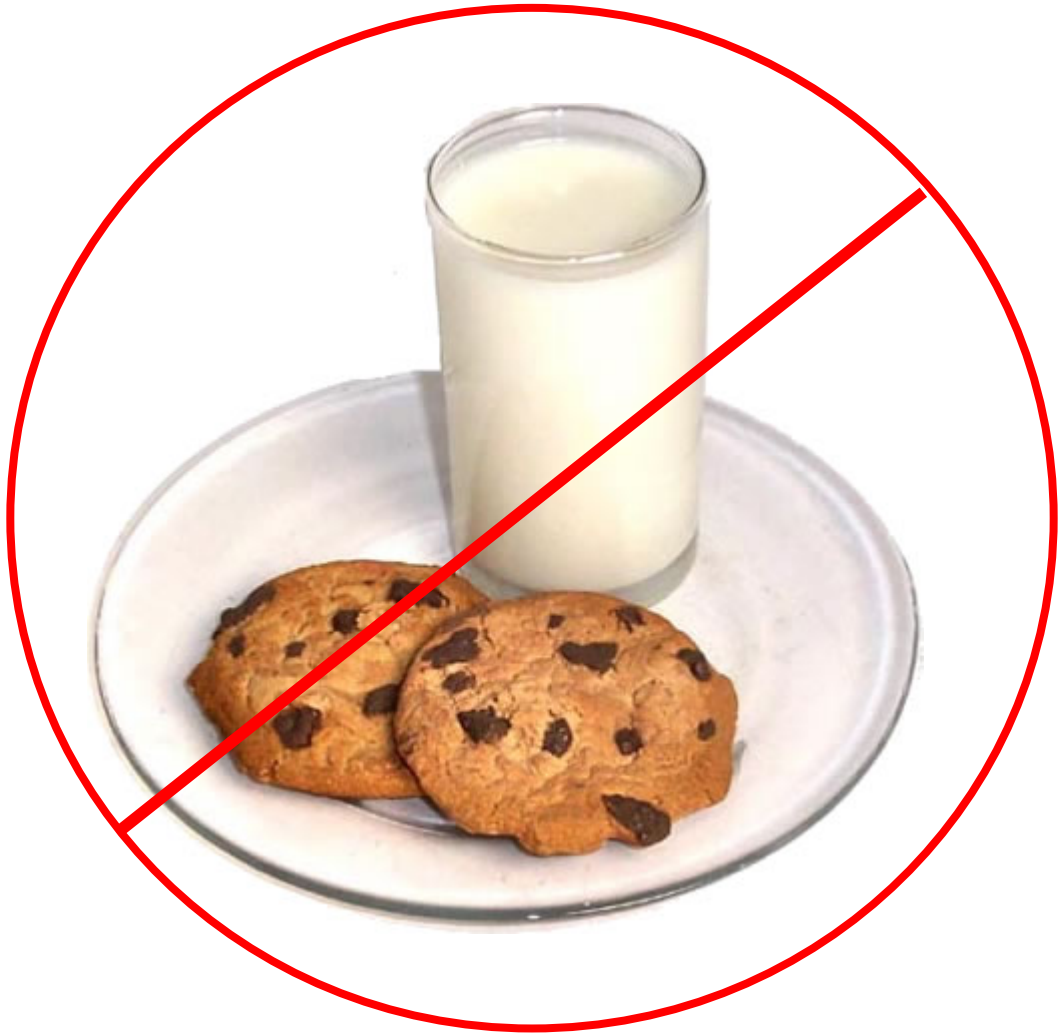
- Breakfast improves attention
- MVIs are usually not needed
  - 2/3 of 292 Children with ASD participating in AS-ATN use Nutritional Supplements Compared to 1/3 in General Pediatric Population (NHANES) *Stewart et al 2015*
- Foods in the US may be highly fortified – an adequate diet may look different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

Do Dietary Interventions Affect Behavior in ASD?

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

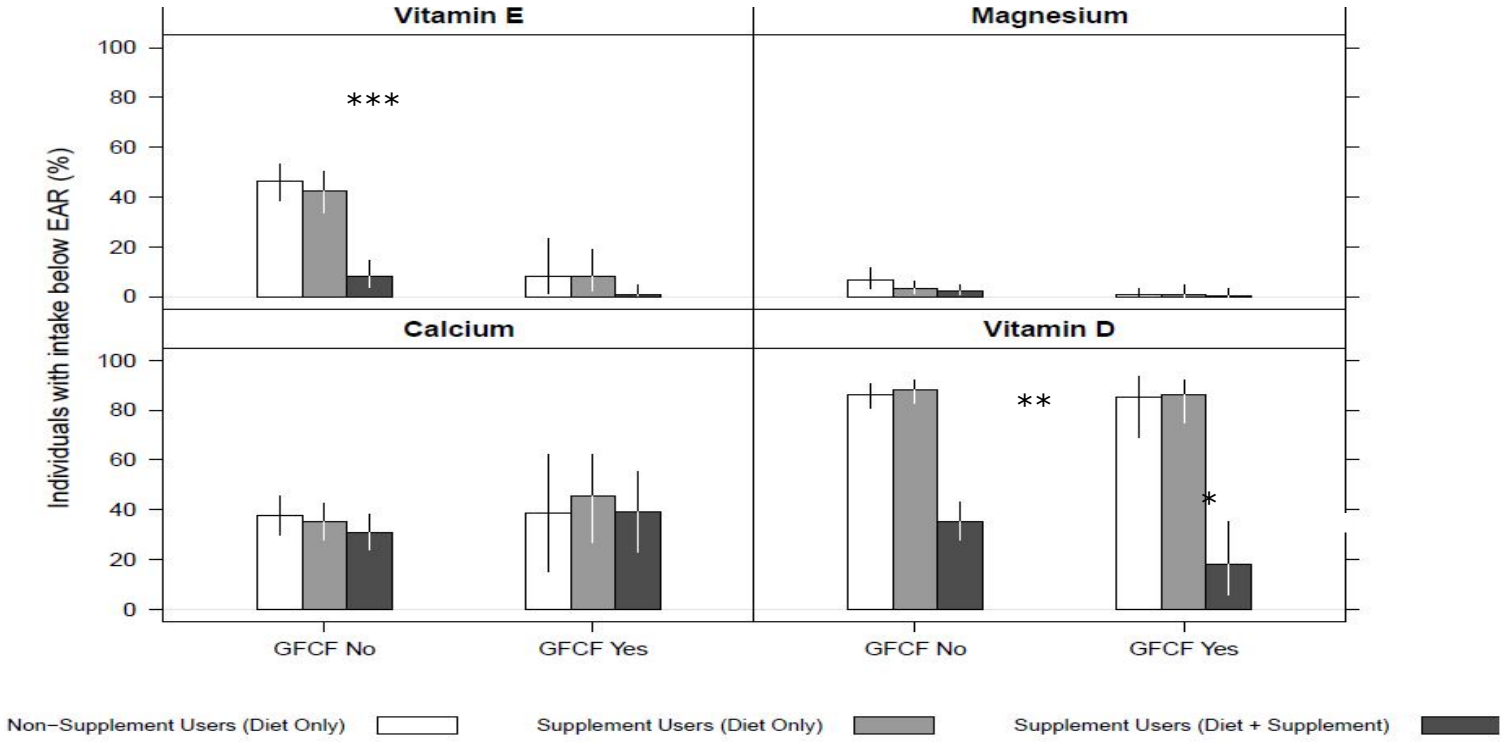
Explanations for Empiric Observations- Require Research Support:

- ***Opioid Hypothesis***
- ***Leaky Gut***
- ***Immunologic Dysregulation***
- ***Alteration of Microbiome***



Author/Year	Sample	Bias	Outcome	Comments
Ghalichi, 2016	N=80	high	GF improved bloating, stomachache, constipation; stereotypies and constipation	GARS2 for behavioral outcome data
Hyman, 2016	N=14 Challenge	Low/moderate	No difference in sleep, stool, behavior	Controlled for ABA
Pederson, 2014	Reanalysis	high	Most likely to respond are 7-9 Yrs with ADHD sm	Whitely, 2010
Pennisi & Klein 2012	387	high	Parents report more effective with GI sm, food allergy or sensitivity	Reported improved social sm
Johnson, 2011	N=22, 3 m	moderate	No change, parallel group single blind RCT , CBCL, direct observe	
Whitely, 2010	N=72, 12m	high	ASD sm improved at 12 but not 24 months	Single blind, did not account for attrition
Elder, 2006, 2007	N= 15	moderate	No difference in symptom severity or language	7/15 better language, not substantiated
Knivsberg, 2002,2003	N=10, 12 m	high	Improvement in cognition, language, social,	Over 1 year

Effect of Gluten Free Casein Free Diet on Nutrient Inadequacies for Select Nutrients in Children with Autism Spectrum Disorders



*** = p < 0.001
** = p < 0.01
* = p < 0.05

Figure 3

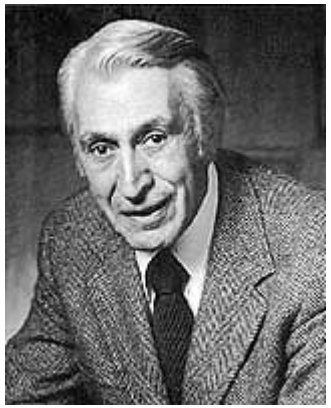
Nutritional Impact of GFCF Diet:

- 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?

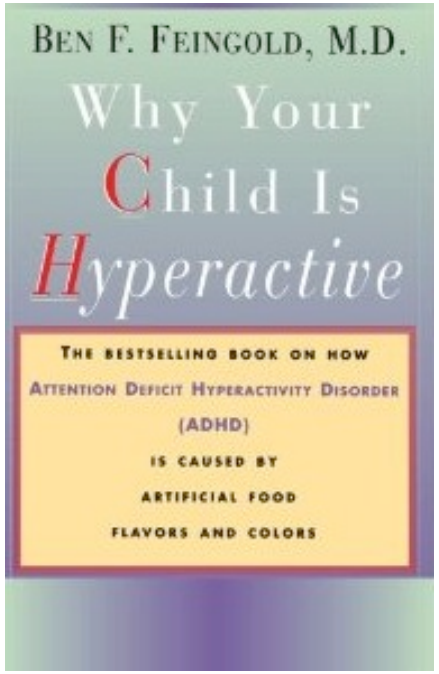
- Modified Adkins Diet vs GFCF vs typical diet (El Rashidy et al 2018)
  - MAD 60% calories from fat, 30% protein, 10% carb
  - Participants 3-8 yrs, behavior therapy 2 x week
  - ATEC and CARS, both improved compared to typical diet, MAD>GFCF for cognitive and socialization by report
  - 5/15 MAD dropped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

Camel Milk

B6

GAP Diet

Modified Atkins Diet

Vitamin A

Coenzyme Q

Zinc

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

Vitamin C

Folinic Acid

Agency for Healthcare Research and Quality–commissioned update of a comparative effectiveness review of therapies for children with ASD (Sathe et al *Pediatrics, 2017)*

MAGNESIUM

Yeast Free Diet

B12

Probiotics

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→

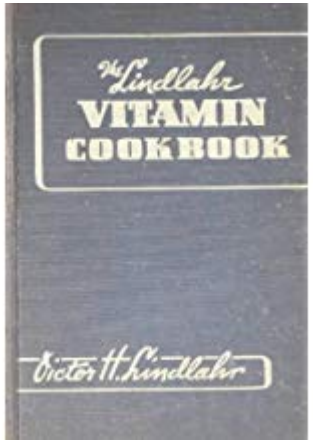
- *Inattention?*

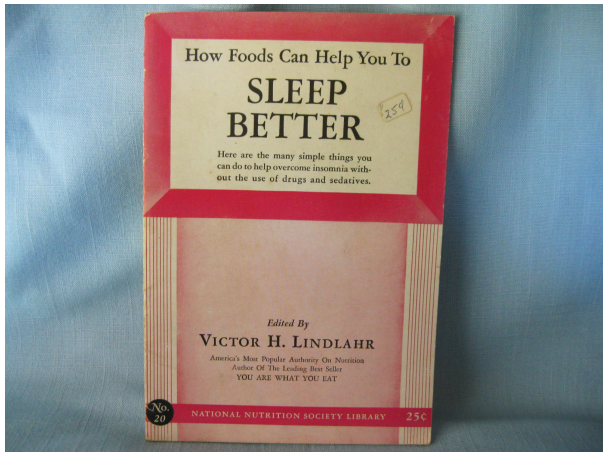
Despite the Absence of Supporting Evidence Dietary Interventions are Popular:

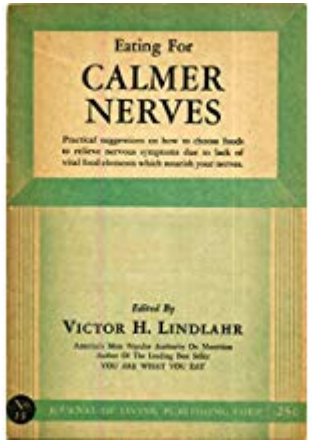
- Alignment with personal and societal views about health and wellness
- Seen as having fewer side effects than prescriptior medicines
- Can be decided upon and managed by the family
- The evidence base for many "conventional therapies" is modest.

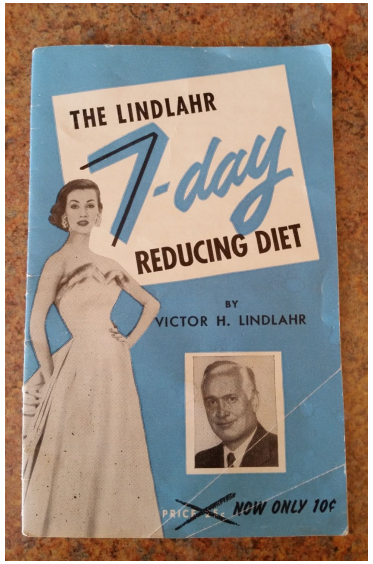
Conclusions:

- ***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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MEDICINE *of* THE HIGHEST ORDER