

The Classic Ketogenic Diet: Evidence, Diet Calculation and Case Reports

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About our Keto Ambassadors





Lindsey Thompson, MS RD CSP LD BASED IN KANSAS CITY, MO

Lindsey Thompson is a registered dietitian in the Comprehensive Epilepsy Center at Children's Mercy Hospital in Kansas City, Missouri, and is currently in pursuit of her PhD in Nutrition from the University of Kansas Medical Center. Lindsey is passionate about the ketogenic diet because of the remarkable difference it makes in the lives of patients, families and caregivers affected by epilepsy and other neurological disorders. Many of her patients seek the diet as a "last resort" and it brings Lindsey great pleasure to deliver optimal outcomes for a family in need. While the concepts

of the ketogenic diet date back to the early 20th century, Lindsey believes we are just now paving the way for modern medicine to seek and employ diet and nutrition as a first-line treatment for both chronic and debilitating disease states.



Zahava Turner, RD CSP LDN BASED IN BALTIMORE, MD

Zahava Turner is a Senior Clinical Pediatric Dietitian, Board Certified in pediatric nutrition working at the Johns Hopkins Hospital in Baltimore, Maryland since 2005. She received her BS and completed her dietetic internship at Queens College CUNY in New York with an emphasis in clinical nutrition and worked for 2 years as a pediatric dietitian at Schneider's Childrens Hospital. Zahava specializes in using the Ketogenic diet for infants and children with epilepsy and has spoken both nationally and internationally at several conferences on the ketogenic and Modified Atkins diet

for epilepsy. She is a co-author of 18 publications and the widely-referenced book Ketogenic Diets 5th edition. Zahava lives in Baltimore with her husband and three children.



Lindsey Thompson

 Consultant - Nutricia North America as Keto Ambassador

Zahava Turner

 Consultant - Nutricia North America as Keto Ambassador

Objectives



- Review research on the classical ketogenic diet
- Describe the basic components of a classical ketogenic diet and ratio
- Calculate a classical ketogenic diet including calories, protein, fat and carbohydrate goals
- Review the classical ketogenic diet induction process
- Recognize a sample meal plan or formula components on the classical ketogenic diet

Ketogenic Diet Basics



- High fat, adequate protein and low carbohydrate
- Mimics the metabolic state of fasting
 - Produces ketones



Who Gets Placed On The Diet?



- Patients who fail the traditional anti-convulsant therapy
- Utilized by a wide variety of ages
- All seizure types
 - Doose epilepsy
 - Infantile spasms
- Minimum time on the diet: 3 months
- Average time on the diet: 1-2 years

Ketogenic Ratio



- Grams of fat: protein and carbohydrate combined
- Example: 4:1 ratio is 4 grams of fat to 1 gram of protein and carbohydrate combined
- Higher the ratio the lower the amount of allowed protein and carbohydrates

Vitamins and Supplements



- Supplementation almost always needed for the diet
- Typically supplement:
 - Complete Pediatric multivitamin/multimineral supplement
 - Calcium
 - Vitamin D
- May need supplements of:
 - Bicarbonate
 - Carnitine
 - Selenium
 - Salt

• Supplements will be discussed later in the workshop

Seizure Tracking



- Utilize Seizure Charts to keep track of diet efficacy
- Describe types of seizures (A, B, C, etc)
- Include ketones for the week
- Daily carb intake
- Can use <u>http://www.seizuretracker.com</u> to help with seizure tracking

Sample Seizure Tracking Log



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
Date:	Date:	Date:	Date:	Date:	Date:	Date:	Weight:
Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	
							Ketones:
							Ketones:
Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	
Date:	Date:	Date:	Date:	Date:	Date:	Date:	Weight:
Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	
							Ketones:
							Ketones:
Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	
Date:	Date:	Date:	Date:	Date:	Date:	Date:	Weight:
Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	
							Ketones:
							Ketones:
Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	
Date:	Date:	Date:	Date:	Date:	Date:	Date:	Weight:
Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	Sz:	
							Ketones:
							Ketones:
Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	Carbs:	

Diet Specifics

• The entire diet is precisely calculated and weighed on a gram scale to provide a specific percentage of fat, carbohydrate and protein.

Example (1 meal; 3:1 ratio; 400kcal)

- 25 g chicken 24 g green beans
- 65 g heavy whipping cream
- 17 g butter
- As with medicine, the diet is highly specific for the child's needs. Even carbohydrates in medicine, lotions and toothpastes are monitored and restricted.

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"American" Diet

Examples of Meals





Meal Plan



Basic Structure

- Heavy Whipping Cream
- Butter/mayonnaise/oil
- Protein
- Fruit or vegetable

Sample Foods

- 40 g 36% heavy cream
- 21 g fat
- 24 g chicken breast
- 11 g broccoli
- 12 g lettuce

Products

Formulas that may be utilized for the ketogenic diet include:

- KetoCal[®] (Nutricia)
 - KetoCal[®] 3:1 Powder (Unflavored)
 - KetoCal[®] 4:1 Powder (Vanilla Flavored)
 - KetoCal[®] 4:1 LQ Liquid (Flavored and Unflavored)
- RCF[®] (Abbott) Ross Carbohydrate Free Formula soy based carbohydrate free formula
 - Used in milk protein allergy
 - Used when carbohydrates must be very limited due to low caloric needs
- KetoVolve[™] (Nutr-e-volultion)
 - Bland flavored powder
- KetoVie[™] 4:1 (Cambrooke)
 - Available in chocolate and vanilla flavors
 - Ready-to-feed liquid



Modular Products

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A variety of modular products may need to be added to ensure nutrient needs are met and ketogenic ratios are correct.

- Lipid
 - Microlipid[®] (Nestle) safflower oil emulsion at 4.5 kcal/mL
 - MCT Oil[®] (Nestle) fractionated coconut oil at 7.7 kcal/mL
 - Liquigen[®] (Nutricia) MCT emulsion at 4.5 kcal/mL
 - Betaquik[™] (Vitaflo) MCT emulsion at 1.89 kcal/mL
 - Carbzero[™] (Vitaflo) LCT emulsion at 1.8 kcal/mL
 - Retail Oils (Olive oil, coconut oil) variable caloric density

Modular Products

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• Carbohydrate

 Solcarb[®] powder (Solace) – carbohydrate powder – maltodextrin - 3.75 kcal/g

 ○ Polycal[™] powder (Nutricia) – carbohydrate powder – maltodextrin – 3.84 kcal/g

• Protein

- Beneprotein[®] (Nestle) whey protein powder 6 gm protein in 7 gm powder
- Complete Amino Acid Mix (Nutricia) 100% amino acid powder – 8.2 g protein in 10 g powder

Baking Mixes/Flours



- CarbQuik[™] (Tova Industries, LLC)
- KetoCuisine[™] (Solace)
- KetoCal[®] (Nutricia)
- Almond flour
- Coconut flour

Blenderized Ketogenic Diet



- Divide feeds into multiple feeds per day (3-6, pending age of the child and enteral feed tolerance)
- Ensure meals are in the correct ratio
- Ensure calorie, protein, and fluid needs are met with all feeds if not consuming any foods orally
- Provide 100% DRI for vitamins and minerals with supplementation

Ketogenic Diet Studies Published







				Seizure Improve	ment at 6 mo, %
Reference	Study Type	Patients, no.	Age Range, yr	>50% Reduction	>90% Reduction
Vining et al., ⁷⁵ 1998	Prosp.	51	1–9	53	29
Freeman et al., ³¹ 1998	Prosp.	150	1-16	51	32
Hassan et al., ⁷⁶ 1999	Retrosp.	52	2-9	67	
Kankirawatana et al.,77 2001	Prosp.	35	0.2-13		75
Nordli et al., ⁷⁸ 2001	Retrosp.	32	0.5-1.5	55	
Kossoff et al., ⁷⁹ 2002	Retrosp.	23	0.5-2	72	39
Coppola et al., ⁸⁰ 2002	Prosp.	56	1-23	27	
Francois et al., ⁸¹ 2003	Retrosp.	29	0.3-12.5	41	
Mady et al., ⁸² 2003	Retrosp.	45	12-19	50	29
Klepper et al.,83 2004	Retrosp.	111	0.1-18	31	17
Vaisleib et al., ⁸⁴ 2004	Retrosp.	54	2-14	65	
Kang et al.,85 2005	Retrosp.	199	0.5-17.5	58	
Bergqvist et al., ⁸⁶ 2005	Prosp.	48	1-14	63*	38*
Eun et al., ⁸⁷ 2006	Retrosp.	43	0.5-4	81	63
Kossoff et al., ⁸⁸ 2007	Retrosp.	30	4-24	63	23
Seo et al., ⁸⁹ 2007	Prosp.	76	0.3-16	79	49
Hamdy et al., ⁹⁰ 2007	Retrosp.	90	0.3-14.8	74	44
Kossoff et al., ²⁸ 2008	Retrosp.	118	0.3-15	71	43
Neal et al., ³² 2008	Prosp.	73	2-16	38*	7*
Freeman et al. ²⁹ 2009	Prosp	20	1_10	80	
Total	1	1,335	0.3-24	56	24

 Table 2. Published Efficacy Studies of the Ketogenic Diet, Retrospective and Prospective, with 20 or More Patients, 1998–2008

Kossoff, Rho *Neurotherapeutics*, 2009

BRIEF COMMUNICATION

A blinded, crossover study of the efficacy of the ketogenic diet

*John M. Freeman, *Eileen P.G. Vining, *Eric H. Kossoff, *Paula L. Pyzik, *Xiaobu Ye, and †Steven N. Goodman

➔ W The ketogenic diet for the treatment of childhood epilepsy: a randomised controlled trial

Elizabeth G Neal, Hannah Chaffe, Ruby H Schwartz, Margaret S Lawson, Nicole Edwards, Geogianna Fitzsimmons, Andrea Whitney, J Helen Cross



Hopkins Double-Blinded Study

Epilepsia © ILAE

- 12-day study period
 - Start of the diet
 - Children with LGS
- Trend towards saccharin superiority in clinical seizures (p=0.07)
 - Median -34
 seizures/day over 12
 days (p=0.003)
- Probably an inadequate placebo state due to fasting twice



Freeman, et al. Epilepsia,

2009







Epilepsia, 50(2):304–317, 2009 doi:10.1111/j.1528-1167.2008.01765.x

SPECIAL REPORT

Optimal clinical management of children receiving the ketogenic diet: Recommendations of the International Ketogenic Diet Study Group

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It takes a team to make the ketogenic diet work!

Team members include:

- MD RN
- RD Pharm D
- Social Worker
- Family of the patient going on the ketogenic diet

Together, everyone must decide on the goals of therapy

Basic Steps to Calculating the KD



- Assess calorie needs
- Assess protein needs
- Assess fluid needs
- Determine appropriate ketogenic ratio
- Calculate diet

Basic Nutrition Assessment Energy Needs



- Aim to achieve normal growth and development for age
 - If under- or overweight, calculate ideal body weight (IBW) for age
- Calculating IBW for Birth 24 months
 - IBW is the weight for the actual length at the 50th %ile
- Calculating IBW for 2-20 years
 - IBW is the weight corresponding to the 50th %ile BMI
 - Ideal BMI x (ht in meters)² = IBW
- Consider factors that affect energy expenditure such as low muscle tone, ventilator dependency or spasticity

Calculation of Energy Needs

- EER using actual or IBW
 - Infants and Toddlers
 - 0-3 Months: (89 x [wt in kg] 100) + 175
 - 4-6 Months: (89 x [wt in kg] 100) + 56
 - 7-12 Months: (89 x [wt in kg] 100) + 22
 - 1-3 Years: (89 x [wt in kg] 100) + 20
 - Children
 - Boys 3-8 Years: 88.5 (61.9 x age) + PA x (26.7 x wt in kg + 903 x ht in cm) + 20
 - Girls 3-8 Years: 135.3 (30.8 x age) + PA x (10 x wt in kg + 934 x ht in cm) + 20
 - Boys 9-18 Years: 88.5 (61.9 x age) + PA x (26.7 x wt in kg + 903 x ht in cm) + 25
 - Girls 9-18 Years: 135.3 (30.8 x age) + PA x (10 x wt in kg + 934 x ht in cm) + 25

• Activity Factors

- Sedentary: Boys 1, Girls 1
- Low Active: Boys 1.13, Girls 1.16
- Active: Boys 1.26, Girls 1.31
- Very Active: Boys 1.42, Girls 1.56



Protein and Fluid Needs

- Protein DRI for actual body weight
 - Infants: 1.52 grams/kg/day
 - Age 1-3 years: 1.1 grams/kg/day
 - Age 4-13 years: 0.95 grams/kg/day
 - Age 14-18 years: 0.85 grams/kg/day
 - Adults: 0.8 grams/kg/day
- Fluid Holliday-Seger Method
 - Weight <10 kg: 100 mL/kg body weight
 - Weight 10-20 kg: 1000 mL (for first 10 kg) + 50 mL/kg for 10-20 kg
 - Weight >20 kg: 1500 mL (for first 20 kg) + 20 mL/kg for >20 kg



Ketogenic Diet Ratio



• Ratio of macronutrients

Grams of fat: grams of protein + carbohydrate

- Typically ranges from 2:1 4:1
- Higher ratios typically result in higher ketosis
- $\circ~$ Individuals will respond differently to the same ratio
- Goal ratios are individualized and vary by institution, typically 3:1 or 4:1
- Goal is typically moderate-large urinary ketones or a serum βhydroxybutyrate (β-OHB) > 2,000 mcmol/mL (>3 mmol/L)
- Often infants and adolescents follow lower ratios (i.e. 3:1) and children are set on a goal ratio of 4:1

Calculating the Diet



- Dietary units determine how many grams of fat, carbohydrate and protein the patient will receive on a given ratio
- They are based on calories/gram in the respective macronutrients

Ratio	Fat Calories	Carb and Protein Calories	Calories per dietary unit
2:1	2 gm x 9 kcal/gm = 18	1 gm x 4 kcal/gm = 4	18 + 4 = 22
3:1	3 gm x 9 kcal/gm = 27	1 gm x 4 kcal/gm = 4	27 + 4 = 31
4:1	4 gm x 9 kcal/gm = 36	1 gm x 4 kcal/gm = 4	36 + 4 = 40

Sample Diet Calculation



Example: a patient's estimated energy needs are 750 kcal/day and their protein needs are 14 grams/day. The patient is started on a 3:1 ketogenic diet.

Dietary Units: Divide the estimated calorie needs by the calories per dietary unit at a 3:1 ratio to get the amount of dietary units in the diet: 750 kcal/31 = 24.2 dietary units

Fat: Multiply the dietary units by the grams of fat in the ratio (3 grams) 24.2 x 3 grams = 72.6 grams of fat

Carbohydrate and Protein: multiply the amount of protein and carbohydrate in the ratio (1 gram) by the dietary units 24.2 x 1 gram = 24.2 grams of protein + carbohydrate

Sample Diet Calculation



- Protein: 14 grams daily (determined previously)
- Carbohydrate: Subtract the number of required grams of protein from the total grams of protein and carbohydrate:

24.2 – 14 grams protein = 10.2 grams carbohydrate

	Calories	Fat	Protein	Carbohydrate
Daily	750	72.6 g	14 g	10.2 g
Per Meal (3 meals/day)	250	24.2 g	4.67 g	3.4 g

Food Composition Data



- Must be calculated in 100 g portions
- Many methods of obtaining information:
 - Excel Spreadsheet

Food	Grams	Calories	Fat	Protein	Carb
Mayonnaise, Hellman's	100	723	80	0.06	0.7
Chicken breast, cooked, no skin	100	156	3.57	31.02	0
Strawberries, raw	100	28	0.3	0.67	5.68
36% Cream	100	344	36	2	3
Oil, olive	100	900	100	0	0

KetoDietCalculator (<u>http://www.ketodietcalculator.org</u>)

Before the Initiation



- Set initial goals prior to admission for the ketogenic diet, such as:
 - $\,\circ\,$ Set schedule of meals and snacks to be eaten at the table
 - Try high fat foods such as heavy cream, butter, avocado, mayonnaise
 - Limit high carbohydrate drinks such as juice, soda and sports drinks. Try alternatives such as diet caffeine free soda or sugar free sports drinks
- Week prior- contact family (f/u on goals, gram scale, admission process)

Diet Initiation



- Work with providers on plans
 - Decide between fasting vs non-fasting initiation
 - Inpatient vs outpatient
- Diet initiation protocol used depends on institution
- Provider to change medications to noncarbohydrate containing forms

Initiation Protocols Fasting vs Non-fasting



Fasting	Non-Fasting
24 hour fast (water or no calorie beverage only) until large ketones are present in the urine	Eat regular meals and drinks up to day of admit
Provide ¼-½ calories at goal ratio (3:1 or 4:1) for 24 hours	Follow protocol on next slide based on route of feeding
Advance daily until at goal calories at goal ratio (3:1 or 4:1) as tolerated	

Initiation Protocols



	Enteral	PO/ Enteral
Day 1	2/3 calories home formula 1/3 calories from ketogenic formula	1:1 Ratio
Day 2	1/3 calories home formula2/3 calories from ketogenicformula	2:1 Ratio
Day 3	Full strength ketogenic formula	3:1 Ratio

Fluids



- Meet 100% of fluid needs as estimated using the Holliday-Seger Method
- If PO fed, set 24-hour fluid goal
 O Give the family a written schedule
- If tube fed, meet fluid needs by incorporating water into formula or through water flushes

Monitoring



Hypoglycemia

- Blood glucose checked at least 4 times daily before meals or feedings
- If <40 mg/dL or 40-50 mg/dL with symptoms treat with 15-30 mL juice or 30 mL D10 bolus

• Acidosis

- Daily metabolic panel: monitor CO₂ level
- If <15 mEq/L, treat with IV bicarbonate (1 mEq/kg)

• Ketosis (goals)

- \circ Serum β -OHB q day (goal > 2,000 mcmol/mL or >3 mmol/L)
- O Urine ketones q void (goal moderate-large)

Education- during initiation



- Training on using a gram scale to measure all food and formula
 - All caregivers must be trained!
- Sick day guidelines
 - Clear liquid guidelines water, Powerade Zero[™], Propel[®] water
 - Half strength formula
- Over the counter products and topicals
- Use of Ketogenic Calculator or App
- Formula (WIC, DME, etc) for home (SW, RD, D/C planner)

Micronutrients

- Meet 100% of DRI's for micronutrients
- Meet normal electrolyte requirements
 - Sodium: 2-3 mEq/kg/day (1mEq = 23 mg)
 - Potassium: 1-2 mEq/kg/day (1mEq = 39 mg)
 - Chloride: 2-3 mEq/kg/day (1mEq = 35 mg)
- PO fed: assume 0% intake of micronutrients and provide:
 - o Multivitamin
 - Calcium + Vitamin D
 - o Phosphorus
 - Potassium/Sodium Chloride
- Formula fed: calculate needs met with formula and fill in the gaps
 - Potassium/Sodium Chloride
- Other supplements may be necessary



Case Study 1



Patient A is a 4 year old typically developing female with epilepsy being put on a 4:1 ketogenic diet. She eats by mouth. Her anthropometrics are as follows: Weight 14.7 kg (22%) Height 99.3 cm (27%) BMI 14.91 (39%). She would be considered "low active".

- Calculate her dietary units based on a 4:1 ratio and her calorie needs
- Calculate her goal grams of fat, protein and carbohydrate for one day
- If she would like to eat 4 meals per day what are her macronutrient needs per meal?

Case Study Diet Calculations



- Calorie needs: 1278 kcals/day
- **Protein needs**: 13.96 g protein/day
- Fluid needs: 1235 mL/day
- **Dietary units**: 1278/40 = 31.95 dietary units
- Grams of fat: 31.95 x 4 = 127.8 g fat
- Grams of protein: 13.96 g protein
- **Grams of carbohydrate**: 31.95 total grams (protein + carbohydrate) 31.95 13.95 g protein = 17.99 g carbohydrate
- **Goals per meal for 4 meals**: 320 kcal, 3.5 g protein, 4.5 g carbohydrate

Case Study 2



Patient B is 6 year-old developmentally delayed male who is Gtube dependent. His calorie needs are 1100 kcal/day. His current weight is 22.1 kg which is at the 56th percentile for age. He is being admitted to the hospital for the ketogenic diet at a goal ratio of 3:1.

- Calculate his protein needs
- Calculate his dietary units for a 3:1 ratio
- Calculate his fluid needs
- Design his G-tube regimen based on the above requirements
 - Which formula(s) would best fit this patient's needs?
 - $\circ~$ What would be an adequate feeding regimen with water flushes?
- What supplements (if any) would this patient need to meet his micronutrient requirements?

Case Study 2 Diet Calculations



- Protein needs: 20.995 g protein
- Fluid needs: 1542 mL
- **Dietary units**: 1100/31 = 35.48 dietary units
- What formula would you use?
 - KetoCal® 3:1
- What is the feeding regimen you would recommend? How much for water flushes?
 - 30 kcal/oz KetoCal[®] 3:1 220 ml formula x 5 with 110 ml water flushes x 5
- What supplements would you recommend?
 - Sodium and potassium salts

Case Study 2 (continued)



- If Patient B were hypometabolic with calorie needs of only 700 per day, how would his regimen change?
- Calculate his dietary units for 3:1 ratio and 700 kcal
- Design his G-tube regimen based on the above information
 - Which formula(s) would best fit this patient's needs?
 - What would be an adequate feeding regimen with water flushes?
- What supplements (if any) would this patient need to meet his micronutrient requirements?

Case Study 2



- **Dietary Units**: 700/31 = 22.5 dietary units
- **Fat** = 67.7 g
- **Protein** = 20.99 g
- Formula choice: RCF®
- Feeding regimen: 30 kcal/oz ketogenic formula 175 mL formula x 4 feeds + 230 mL water x 4
- Supplements: ½ multivitamin, calcium + vitamin D, sodium/potassium salts

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