



A guide for the practical implementation of the
Classical Ketogenic Diet (CKD) for the dietary management
of epilepsy and neurometabolic disease.



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Disclaimer

This practical guide:

- Is intended for use as a general aid to implementing the ketogenic diet (KD) in children aged over 1 year, adolescents and adults diagnosed with epilepsy or an inherited neurometabolic disorder, for example, Glut-1 Deficiency Syndrome (Glut-1 DS) or Pyruvate Dehydrogenase Deficiency (PDHD), where its use is indicated and evidence based.
- Is primarily focused on the dietetic application of the KD, and classical ketogenic diet (CKD) in particular, not the clinical management associated with its use.
- Does not relate to the challenge of the KD and CKD implementation in infants i.e. those under 12 months of age. Further guidance from more specialist resources should be sought for this group.
- Is only to be used by qualified healthcare professionals.
- Is not for use by patients or their parents or caregivers.
- For general information only and must not be used as a substitute for professional medical advice or treatment.

The information, although accurate and based on current best practice in the UK at the time of publication, is subject to change as use of the KD evolves.

It is the sole responsibility of the Multi-Disciplinary Clinical Team (MDT), i.e. a dedicated '**keto-team**', to ensure patients managed on the KD are suitable to undergo this form of dietary therapy and they undertake and implement all the assessments, procedures, investigations and monitoring required in accordance with locally agreed procedures specific to the intervention. The term '**keto-team**' is a generic description for those healthcare professionals (for example, dietitians, clinicians, nurses) involved in the implementation, follow-up and care of patients on a KD.

We advise this guide is read in conjunction with your local and national protocols and general recommendations for the use of the KD and CKD in the dietary management of epilepsy and neurometabolic disease.

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For information on the ketogenic diet, VitaFlo products for the use in ketogenic diet and recipes, visit the VitaFlo websites:

www.vitafloweb.com

www.myketogenicdiet.com

Throughout this guide, reference is made to other VitaFlo resources for the KD, which can be accessed on the VIA website

www.nestlehealthscience.com/VitaFlo/VIA



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Introduction

The CKD is the original KD¹⁻³. A ratio expresses the proportion of fat to protein plus carbohydrate combined, e.g. a 3 to 1 CKD indicates that for every 3g of fat, there is 1g of protein and carbohydrate combined. Although the higher ratios of 4 to 1 or 3 to 1 are potentially the most ketogenic, a lower ratio diet, e.g., 2 to 1, may be as efficacious for the dietary management of epilepsy, more palatable and better tolerated. On the CKD, fat intake is very high (87 – 90% of daily energy requirements), carbohydrate very restricted, and protein intake tightly controlled. The chosen ketogenic ratio, together with the daily energy and protein requirements, are central to the dietary prescription. The CKD is always prescribed and implemented on an individual patient basis. To ensure daily macronutrient content is correct and the ketogenic ratio consistent, accurate calculation of the daily meal plan, meals, snacks and recipes is very important⁴⁻¹².

Although the planning and implementation of the CKD has complexity, it has proven efficacy in the dietary management of epilepsy and neurometabolic disease, especially in children¹³⁻¹⁵. The aim of this guide is to provide a basic overview and description of the CKD from a dietetic perspective.

1.0 Overview of the practical dietary implementation of the CKD for epilepsy and neurometabolic disease.

The process of planning and implementing the CKD can be divided into three phases, outlined in Figure 1. These are explained in more detail in sections 2.2 - 5.0.

Figure 1: Phases One, Two and Three of planning and implementing the CKD.

Phase One (2.0)

Pre-diet preparation and planning

Carry out a dietetic and anthropometric assessment.

Formulate and plan the CKD on an individual patient basis, in **8 STEPS**:

- STEP 1** Obtain actual body weight (kg) and estimate energy requirements (kcal per day).
- STEP 2** Choose the ketogenic ratio.
- STEP 3** Determine the daily protein requirement (g).
- STEP 4** Calculate the amount of fat per day (g).
- STEP 5** Calculate the amount of carbohydrate per day (g).
- STEP 6** Construct a daily meal plan.
- STEP 7** Create meals and snacks.
- STEP 8** Devise a transition schedule.

Provide training session(s) and resources on the CKD to patients/caregivers.

In preparation for starting the CKD, advise on relevant dietary changes that can be made for 1-2 weeks beforehand.

Phase Two (3.0)

Starting the CKD

Initiate the transition schedule to transfer to the calculated meal plan.

Phase Three (4.0)

Monitoring and follow-up

Provide ongoing, regular contact, review and support.

Recalculate and adjust the CKD meal plan, via **STEPS 1 to 8**, as required, according to individual patient nutritional and clinical needs.

2.0 Phase One - Pre-diet preparation and planning

A period of time prior to implementing the CKD is essential, both for the **keto-team** and caregivers. During this time, preparation for starting the CKD should include:

Dietetic and anthropometric assessments

Both these evaluations are essential for the CKD. They are described in the Vitaflo document 'Guidelines for the practical implementation of the ketogenic diet for the dietary management of epilepsy and neurometabolic disease' (section 4.0). The information gathered can be used to estimate daily energy requirements (which may differ from that recommended for age), and to help tailor personal advice and guidance for implementing and following the diet.

2.1 Calculating and planning the CKD - STEPS 1 to 8

The CKD is always planned on an individual patient basis, to meet unique dietary requirements.

STEP 1 From anthropometric and dietetic assessments, obtain actual body weight (kg) and estimate energy requirements (kcal per day).

STEP 2 Choose the ketogenic ratio (Table 1).

To promote dietary acceptance and tolerance, the CKD can be started at a lower ratio initially (e.g. 2 to 1, or lower), then increased incrementally up to the higher, target ratio e.g. 3 to 1, 4 to 1 (or as per **keto-team** policy). See also **STEP 8**, 'Devise a transition schedule'.

STEP 3 Determine the daily protein requirement in grams (g)

Choose an appropriate amount in grams of protein per kg actual body weight.

- Traditionally, 1g protein per kg actual body weight is used for children and adults¹⁻³.
- During periods of rapid growth, e.g. for younger children, up to 1.5g protein per kg actual body weight is advised^{4,5}.
- If the patient is very underweight for their age, or height, their ideal body weight can also be used to guide the choice of the amount of protein per kg for their diet calculation.
- Alternatively, the WHO⁶ or EFSA⁷ recommendations for minimum safe levels of protein intake can be used^{4,5}. When daily protein requirements for the CKD are calculated from these values, it is vital that the protein is of High Biological Value (HBV) to provide a source of all nine essential amino acids⁵.

These recommendations, expressed as grams of protein per kg actual body weight, are:

Children and adolescents (depending on age and sex): 0.84 - 1.31g per kg.

Adult men and women (19 years and above): 0.83g per kg.

Calculation:

Chosen amount of protein, g per kg **x** actual body weight (kg) = daily protein requirement (g)

STEP 4 Calculate the amount of fat per day (g)**AND****STEP 5 Calculate the amount of carbohydrate per day (g)**

One method for calculating the daily amounts of each of these two macronutrients is by using the proportions (or percentages, %) of energy from fat, and protein and carbohydrate combined, in the chosen ketogenic ratio⁴. This is shown in Tables 1 to 3.

- **Table 1** gives the % of energy from each macronutrient, according to the ketogenic ratio.
- **Table 2** shows how to calculate grams of fat and carbohydrate from the chosen ketogenic ratio and the daily protein requirement (**STEPS 1 to 5**).
- **Table 3** is an example of the calculation of amounts of macronutrients, in grams, for a 3 to 1 ratio CKD.

Table 1: Percentage of energy from fat, and protein and carbohydrate combined, by ketogenic ratio^{4,5}.

Ratio	Approximate % of energy from fat	Approximate % of energy from protein and carbohydrate combined	Total %
1 to 1	69	31	100
1.5 to 1	77	23	100
2 to 1	82	18	100
2.5 to 1	85	15	100
3 to 1	87	13	100
3.5 to 1	89	11	100
4 to 1	90	10	100

For energy values, calculation symbols and measurement units, see Appendix 1 (7.0).

Table 2: Calculation of grams of fat and carbohydrate from the chosen ketogenic ratio and daily protein requirement (**STEPS 1 to 5**).

STEP 1	Obtain actual body weight (kg) and estimated daily energy requirement (kcal).	
STEP 2	Choose the ketogenic ratio. From Table 1 , identify % of energy from macronutrients.	
STEP 3	Protein Chosen amount of protein, g per kg X actual body weight (kg)	= g of protein per day
STEP 4	Fat (Daily energy requirement, kcal) X (% of fat in chosen ratio) $\div$ 100 Daily energy from fat $\div$ energy per g fat (9 kcal per g)	= Daily energy from fat (kcal) = g of fat per day
STEP 5	Carbohydrate (Daily energy requirement, kcal) X (% of protein and carbohydrate combined in chosen ratio) $\div$ 100 Daily energy from protein and carbohydrate combined (kcal) $\div$ energy per each gram of protein and carbohydrate (4kcal per g) Protein (g) and carbohydrate (g) combined per day - daily protein requirement (g) (from STEP 3)	= Daily energy from protein and carbohydrate combined (kcal) = g of protein and carbohydrate combined per day = g of carbohydrate per day*

* If the amount of carbohydrate calculated is very small, or equals zero grams or a negative value, refer to Appendices 2 and 3 (7.0) for information on adjusting the calculation.

Table 3: Example of the calculation of a 3 to 1 ratio CKD.

STEP 1	Weight: 20kg Daily energy requirement: 1500kcal	
STEP 2	Chosen ketogenic ratio - 3 to 1 From Table 1 , the % of energy from macronutrients in a 3 to 1 ratio are: Fat: 87% Protein and carbohydrate combined: 13%	
STEP 3	Protein Chosen amount: 1g per kg actual body weight, therefore, 1g x 20kg	= 20g protein per day
STEP 4	Fat (1500kcal x 87) ÷ 100 1305kcal ÷ 9	= 1305kcal = 145g fat per day
STEP 5	Carbohydrate (1500kcal x 13) ÷ 100 195kcal ÷ 4 49g - 20g (daily protein requirement from STEP 3)	= 195kcal = 48.8g protein and carbohydrate combined per day (round up to 49g) = 29g carbohydrate per day
	Per day	Fat 145g Protein 20g Carbohydrate 29g
	Ratio = g fat ÷ (g protein + g carbohydrate)	145g ÷ (20g + 29g) 145g ÷ 49g = 3 to 1

An alternative method for calculating the CKD is by using Dietary Units. This approach is described by Kossoff et al.⁸

STEP 6 Construct a daily meal plan

The daily meal plan is formulated for the individual according to their unique dietary needs. As well as the grams of macronutrients per day calculated in **STEPS 2-5**, information gathered from their dietary assessment, is also used, including their:

- estimated daily energy requirement.
- usual intake of meals and snacks, with regard to number, frequency and relative energy content.

To promote ketosis on the CKD, meals and snacks are best consumed on a regular basis throughout the day. If this is the typical eating pattern of the patient, this can be replicated in the CKD meal plan. If their usual eating habits are erratic, and/or food portion sizes are variable, a more structured and balanced daily meal plan can be established.

The calculation of the macronutrient content of each meal and snack in the daily meal plan is described below, and an example shown in **Table 4**, using the results previously calculated in **Table 3**.

1. Choose the number of meals and snacks to be included in the daily meal plan.
2. Apportion an energy content for each meal and snack, aiming for an even distribution throughout the day, by either:
 - basing the energy content of the ketogenic meals and snacks on those usually eaten;
 - OR
 - dividing up the daily energy requirement (from **STEP 1**) into the desired number of meals and snacks.

For either methods, check the energy values from each meal and snack, when all added together, equals the daily energy requirement (from **STEP 1**).

Table 4: Example of how to apportion the energy content of meals and snacks for a daily meal plan, from the results calculated in **Table 3**.

Daily energy requirement and grams of each macronutrient:	1500kcal 145g fat 20g protein 29g carbohydrate
Chosen ketogenic ratio	3 to 1
Chosen energy values for meals and snacks, number and frequency	3 x 350kcal meals (breakfast, lunch and dinner) and 3 x 150kcal snacks (mid-morning, mid-afternoon and supper).
Total energy per day	$(3 \times 350) + (3 \times 150) = 1050 + 450 = 1500\text{kcal}$

3. Then, for each macronutrient:
 - Divide the energy content of the meal or snack by the daily energy requirement (from **STEP 1**).
 - Next, multiply by the grams of macronutrient per day (from **STEPS 3, 4 and 5**).
 - The result gives the grams of macronutrient per meal or snack. An example is shown in **Table 5**.
4. This method keeps the ketogenic ratio consistent, by ensuring each meal and snack is also in that ratio.
5. The final part of **STEP 6** is to put together the daily meal plan, showing each meal and snack, and the amount in grams of each macronutrient they contain. An example of an individual daily meal plan is illustrated in **Table 6**.

Table 5: Calculation of grams of macronutrients per meal and snack (from **Table 4**).

Per meal, 350kcal		g per meal
Fat	$(350\text{kcal} \div 1500\text{kcal}) \times 145\text{g}$	= 33.8g
Protein	$(350\text{kcal} \div 1500\text{kcal}) \times 20\text{g}$	= 4.7g
Carbohydrate	$(350\text{kcal} \div 1500\text{kcal}) \times 29\text{g}$	= 6.8g

Per snack, 150kcal		g per snack
Fat	$(150\text{kcal} \div 1500\text{kcal}) \times 145\text{g}$	= 14.5g
Protein	$(150\text{kcal} \div 1500\text{kcal}) \times 20\text{g}$	= 2.0g
Carbohydrate	$(150\text{kcal} \div 1500\text{kcal}) \times 29\text{g}$	= 2.9g

Table 6: Example of a daily meal plan, showing the amounts of macronutrients per meal and snack calculated in **Table 5**.

	Fat (g)	Protein (g)	Carbohydrate (g)	Energy (kcal)
Breakfast	33.8	4.7	6.8	350
Mid morning snack	14.5	2.0	2.9	150
Lunch	33.8	4.7	6.8	350
Mid afternoon snack	14.5	2.0	2.9	150
Dinner	33.8	4.7	6.8	350
Supper snack	14.5	2.0	2.9	150
Daily totals (rounded)	145	20	29	1500

Handy Hint

Assigning the same energy value to all meals means they can be used interchangeably in a meal plan, as macronutrient quantities are the same, e.g. a breakfast can also be a lunch.

This also applies to snacks.

STEP 7 Create meals, snacks and recipes

These are always generated on an individual patient basis to meet unique dietary requirements. Use the quantities of fat, protein and carbohydrate calculated for the daily meal plan (**STEP 6**) to calculate meals, snacks and recipes from suitable ingredients. Include, where possible, favourite and/or familiar foods and flavours, as even small amounts may aid acceptability and help the CKD be established. Too many suggestions or choices may be overwhelming at first. A small selection, e.g. 5-6 meals and 2-3 snacks, will be enough initially. This will also save dietetic time until the CKD has been fully implemented and its efficacy determined.

Websites providing reliable advice, ideas and suggestions for meals, snacks and recipes suitable for the CKD are e.g. myketogenicdiet.com, matthewsfriends.org and charliefoundation.org. However, these may need adapting to suit the individual dietary requirements of the patient and to fit into their daily meal plan. Encourage those involved in catering for the diet to practice making up meals, snacks and recipes before the CKD starts, and to give opportunity for the patient to try them beforehand.

There are several options for calculating meals, snacks and recipes:

1. Manually, using country-specific information sources for the nutritional composition of foods, e.g. for the UK¹⁰.
2. Manually, using the food choices system⁷.
3. Using a computer program designed for the KD, e.g. the Electronic Ketogenic Manager (EKM)⁹. This package accesses a UK database, but information for the nutritional composition of foods used in other countries can be entered. Alternatively, comparable country-specific versions of the EKM are available. These programs can help create meals, snacks and recipes on an individual basis accurately and quickly, and also enable a wide variety of foods to be included in the diet.

Table 7 shows examples of meals and snacks created from the daily meal plan in **Table 6**. The EKM⁹ has been used to determine quantities of foods in grams that provide the amounts of macronutrients calculated for each meal and snack as closely as possible. This ensures the ketogenic ratio of 3 to 1 is consistent throughout the day, and energy requirements adequately met.

Once the CKD has been established, if it proves efficacious and is appropriate, patients and/or caregivers can be trained to use a KD meal planner program to create their own recipes, meals and snacks, according to their own specific dietary prescription.



These pictures are examples of meals, snacks and recipes created for the CKD using the EKM. Visit www.myketogenicdiet.com for further details.

Tips for creating meals, snacks and recipes

Foods providing PROTEIN

This macronutrient is essential for growth, maintenance and repair of body tissues. Therefore, it is vital the amount calculated to meet individual, daily requirements in **STEP 3** is consumed. If intakes are compromised, e.g. by a reduction in the total amount provided from the diet, or if insufficient HBV protein is included, this may have a negative impact on health. To supply all nine of the essential amino acids, meat, fish, eggs or dairy foods should be included daily, and sole use, or over-reliance, on plant sources of protein, e.g. beans, pulses, nuts and seeds avoided. This is particularly important if protein requirements are calculated using values for minimum safe levels of protein intake^{7,8} in **STEP 3**. When creating meals and snacks for the the CKD, e.g. when using the EKM⁹:

- Use the amount of protein in grams required in the meal or snack (from the daily meal plan, **STEP 6**) as the starting point of the calculation; determine the quantity in grams of a HBV protein food that will provide this and aim to keep it constant.
- Foods used to provide carbohydrate (e.g. fruit, vegetables, nuts) typically contain small amounts of protein. Take care that this contribution does not significantly reduce the quantity of HBV protein food used, to avoid compromising the overall intake of protein.

Foods providing FAT and CARBOHYDRATE

Once the amount of protein in the meal, snack or recipe is fixed, add quantities of foods supplying fat and carbohydrate to meet the required amounts in grams. Then, 'tweak' carefully to achieve the target ketogenic ratio and energy content.

Achieving the ketogenic ratio

In general, when adjusting quantities of foods to meet the required grams of macronutrients, follow these principles for rounding to the nearest whole gram:

- to achieve the target ketogenic ratio - round grams of fat UP and round grams of carbohydrate DOWN;
- to meet protein requirements more adequately - round grams of protein UP in preference to carbohydrate.



Table 7: Examples of meals and snacks created using the EKM⁹ using the daily meal plan in **Table 6**.

Aim per day: 1500kcal; 145g fat, 20g protein, 29g carbohydrate.

Meal or snack	Food ingredient and weight	Fat g	Protein g	Carbohydrate g	Energy kcal
Breakfast Strawberry creamy yogurt [^]	Blend together: Double cream (50% fat), 54g Greek yogurt, plain (10% fat), 63g Strawberries, 47g	33.9	4.7	6.8	351
Mid-morning snack Egg and red pepper mayonnaise	Mix together: Mayonnaise [#] , 10g Olive oil, 6g Hard-boiled egg, whole, 10g Red pepper, raw, 61g	14.6	2.0	2.9	150
Lunch Cheesy sweet potato and spring onions	Fry together: Olive oil, 25g Sweet potato, boiled, 28g Spring onions (bulbs and tops), raw, 8g Mix with: Cream cheese [*] , 21g Cheddar cheese, 12g	33.8	4.7	6.8	350
Mid-afternoon snack Blackberry almond chocolate [^]	Mix together: Butter, 14g Almonds, ground, 4g Cocoa powder, 3g Blackberries, raw, 44g	14.5	1.9	2.8	150
Evening meal Roast chicken and vegetables Pears and cream	Fry together: Olive oil, 26g Chicken, light meat, raw, 17g Carrots, raw, 21g Peppers, green, raw 16g Mix together: Double cream (50% fat), 15g Pears, fresh, raw, 45g	33.9	4.7	6.8	351
Supper Almond milk drink [^] , cheese and apple	Mix together: Almond milk unsweetened, 158g Olive oil, 11g Apple, raw, 23g Cheddar cheese, 5g	14.5	2.0	2.9	150
Daily totals (g)		146.1	21.9	27.1	1514

[^] Add sweetener and/or sugar free flavoring, to taste (optional)[#] Standard, retail^{*} Philadelphia™, (UK)

⊗ STEP 8 Devise a transition schedule

This is a plan that can be followed by the patient to transfer over to the CKD. Its purpose is to introduce the CKD over a period of time. This approach allows adjustment to the new diet, and can be amended to suit their individual clinical needs, response, dietary acceptance and tolerance. The duration of the transition schedule can be made over a few days or more slowly, e.g. over several weeks, as per the individual and **keto-team** policy. During this time, monitoring and input is essential provide support and ensure the well-being of the patient and caregivers.

Two suggestions for transitioning to the CKD are:

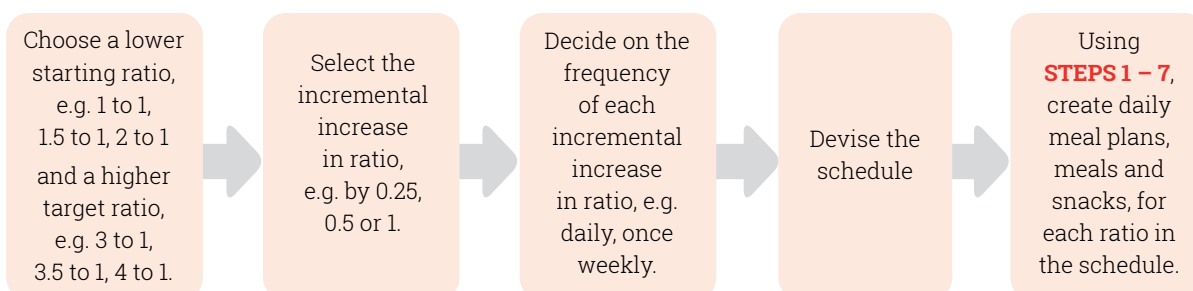
Option 1: Starting at a low ketogenic ratio and increasing incrementally up to the chosen or target ketogenic ratio from **STEP 2**. An overview of this method is shown in **Figure 2**, and examples provided in **Table 7** and **Table 8**.

OR

Option 2: Giving meals and snacks in the chosen ketogenic ratio (from **STEP 2**), in conjunction with reducing quantities of milk or fruit juice. This method is described on the following page and illustrated in **Table 9** and **Appendix 4 (7.0)**.

Option 1

Figure 2: Overview of planning a transition schedule from a normal diet to the CKD by incremental increase in ketogenic ratio.



Note: The ratio of fat to protein and carbohydrate combined in a regular diet is approximately 0.3 to 1.

Table 7: Example of a transition schedule by daily, incremental increases in the ketogenic ratio of 0.5, up to the target ratio of 3 to 1.

	Ratio
Start - Day 1	1 to 1
Day 2	1.5 to 1
Day 3	2 to 1
Day 4	2.5 to 1
Day 5 onwards	3 to 1

Table 8: Example of a transition schedule to a CKD by weekly incremental increases in the ketogenic ratio of 1, from a starting ratio of 2 to 1, up to a target ratio of 4 to 1.

	Ratio
Start - Week 1	2 to 1
Week 2	3 to 1
Week 3 onwards	4 to 1

Option 2

This may be a useful approach for transitioning those that like drinking milk or fruit juice onto a ketogenic meal plan.

- Milk - whole, semi-skimmed, skimmed or formula - is given as a combined source of protein and carbohydrate (approximately 10g per 100ml⁹) with ketogenic meals and snacks at the target ratio.
- Alternatively, pure unsweetened fruit juice, e.g. orange, apple, can be used to provide carbohydrate (approximately 10g per 100ml⁹).
- The volume of milk (or fruit juice) is decreased over several days, thereby increasing the ketogenic ratio. Energy intakes will adjust accordingly.

Method

1. Using the daily macronutrient requirements and daily meal plan calculated in **STEPS 1 to 5**, create a selection of meals and snacks at the chosen target ketogenic ratio. Meals and snacks are given at the chosen ratio (from **STEP 2**) throughout the schedule.
2. Decide on an acceptable amount in grams of milk or fruit juice that will be readily consumed by the patient initially per day, e.g. 300g, 450g and over how many days the transition is to take, e.g. 3 days, 5 days, 7 days.
3. Plan a schedule so that incremental reductions in the amount of milk or fruit juice consumed are made daily, e.g. this could be done on a percentage basis, as shown in **Table 9**.
4. For each day of the schedule, divide up the required amount of milk or fruit juice evenly and proportionally, so some is taken at each meal and snack at the chosen, target ketogenic ratio. This will keep the ratio consistent throughout the day.

An example of a transition schedule using milk is shown in **Table 9**. In this plan, the milk is discontinued on day 6, and the meals and snacks at the chosen ketogenic ratio continued.

Further details are available in **Appendix 4, Table iii (7.0)**. This gives an example of a transition schedule from a regular diet for the 3 to 1 diet plan in **Tables 4 and 5**.

Table 9: Example of using milk or fruit juice to transition to a CKD over 6 days, in conjunction with meals and snacks at the chosen ketogenic ratio.

Day	Relative amount of milk or fruit juice	
1		100%
2		75%
3		50%
4		25%
5		12.5%
6		

Decreasing amount of milk or fruit juice

Increase in ketogenic ratio

2.2 Teaching session

The CKD can be daunting and challenging for patients and caregivers to undertake, due to its complexity, the need for precision with weighing of foods and requirement for strict adherence. Therefore, a period of pre-diet training, provided by the **keto-team** is vital. This will aid understanding of the CKD and help build confidence in its application. In addition, there are many practicalities around the day-to-day application of the diet, both inside and outside of the home environment, that need to be organised and put in place beforehand. **Figure 3** gives suggestions for the areas to cover when training about the CKD. Education may need to be extended to those caring for the patient outside of their home, e.g. to other relatives, and at school, college or a respite facility. During this process, some individuals will require a greater amount and level of input, support and guidance than others, as everyone will have their own unique learning style and ability.

Figure 3: Main dietary principles and advice to provide to patients/caregivers during Phase One - Pre-diet preparation and planning for the CKD.



* In the CKD, dietary fibre is not counted as carbohydrate.

3.0 Phase Two - Starting the CKD

Making specific pre-diet changes to the usual diet (e.g. less carbohydrate, more fat; establishing a regular meal and snack pattern) can help accustom the patient to their new regime. Patients/caregivers will need time to prepare, learn and ideally practice making up meals and recipes before starting the CKD. Changing over to the CKD can be difficult as meals and snacks are much smaller than those in a regular diet, as well as looking and tasting different. Initial acceptance may be poor. Introducing the CKD at a lower ketogenic ratio and increasing this over several days up to the chosen (or target) ketogenic ratio can help facilitate tolerance of the alteration in macronutrient content. Maintaining an adequate energy intake during this period is crucial as hunger may make acceptance of the CKD poor.

Depending on local **keto-team** policy, the CKD can be initiated at home or in hospital. If starting at home, the **keto-team** should maintain close contact with the patient/caregivers. Careful monitoring of dietary intake, levels and of epilepsy is vital to establish clinical efficacy and ensure well-being.

There is no set or recommended timescale for transitioning onto the CKD. Progression up to the chosen (or target) ketogenic ratio (**STEP 2**) will be dependent on factors such as clinical need, dietary tolerance, acceptance and level of ketosis achieved or desired.

4.0 Phase Three - Monitoring and follow-up for the CKD

4.1. During the first three months

- Regular contact and support is essential, particularly at the start.
- Those with feeding difficulties, on tube feeds and/or with poor nutritional status may need more frequent review to ensure individual dietary requirements are being adequately met.
- At each interaction, assess dietary intake and adherence to the calculated daily meal plan.
- Check fluid intake is adequate for hydration, and a daily micronutrient supplement being taken.
- 'Fine tune' on an individual basis in relation to efficacy and any diet related side effects that manifest^{6-8,11,12}.
- Review body weight and use as a guide for updating daily energy requirements. Re-calculation of the CKD prescription may be required to ensure an appropriate energy intake - follow **STEPS 1 to 7** to update the daily meal plan and create new meals and snacks.
- Consider the ketogenic ratio in relation to the efficacy of the dietary management of symptoms of epilepsy management - does it need to be adjusted down, or be increased slightly? If so, follow **STEPS 1 to 7** to adjust the diet plan and meals and snacks.
- A source of MCT (oil, emulsion, powder) can be incorporated into a CKD, e.g. to enhance ketosis¹². For further details, refer to the VitaFlo resources for the use of MCT in the KD.
- Check on the 'day -to day' application and practicalities of the CKD and advise or encourage as required. Provide further education, support and information as needed, e.g. on foods providing fibre, eating away from home, additional recipes or suggested meal plans.

4.2. After three months

The decision to continue or stop the CKD is typically made at this time point depending on clinical efficacy achieved and/or dietary adherence, in consultation with the **keto-team**, patient and/or caregivers.

If continuing with the CKD:

- Repeat the review and 'fine tuning' processes outlined above, as required (and as per **keto-team** policy).
- Regularly assess growth in children and adolescents; update their CKD prescription as required.
- Consider providing training on the use of a ketogenic meal planner, e.g. EKM⁹.

5.0 Discontinuing the CKD

Two suggested approaches are:

Option 1: Gradually reducing the ketogenic ratio by 0.25, 0.5 or 1 at an agreed rate, e.g. daily, weekly or monthly, depending on individual seizure response and/or ketone levels, as illustrated in **Table 11** and **Table 12**. (Note: This is the reverse of the process shown in **STEP 8** - Devise a transition schedule).

Table 11: Example of decreasing the ketogenic ratio by increments of 0.5.

Starting ratio: 3 to 1.

Target: regular diet (ratio approximately 0.3 to 1).

Chosen frequency and duration of ratio increase: weekly

	Ratio
Week 1	2.5 to 1
Week 2	2 to 1
Week 3	1.5 to 1
Week 4	1 to 1
Week 5 onwards	Regular diet

Table 12: Example of decreasing the ketogenic ratio by increments of 1.

Starting ratio: 4 to 1.

Target ratio: regular diet (approximately 0.3 to 1).

Chosen frequency and duration of ratio increase: monthly

	Ratio
Month 1	4 to 1
Month 2	3 to 1
Month 3	2 to 1
Month 3 onwards	Regular diet

Option 2: Gradually swapping over ketogenic meals and snacks for regular ones over an agreed time period, e.g. daily, weekly.

Table 12: Exchanging ketogenic meals and snacks for regular ones.

Key: Regular meal or snack CKD meals or snacks

Timeline for change, e.g. daily, weekly	Breakfast	Lunch	Dinner	Snacks
1				
2				
3				
4				

Notes on discontinuing the CKD

- Quantities of foods and their variety will change and increase at meals and snacks as the discontinuation progresses due to the reduction in total fat content. This can be disconcerting for caregivers after a period of precise portion control and restricted food selection.
- As well as reassurance, providing an individual meal plan as an example of a balanced diet may be useful, to help guide macronutrient and energy intakes once the transition back to a regular diet is completed.

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Appendix 1

Energy values, calculation symbols and measurement units

Energy values used in calculations⁷

per g	kcal
Fat LCT	9
MCT	9
Protein	4
Carbohydrate	4

Calculation Symbol

Plus (or addition)	+
Minus	-
Divide	÷
Multiply	x
Percentage	%
Equals (or result)	=

Measurement Unit

Kilocalorie (energy)	kcal
Gram	g
Kilogram	kg
Milliliter	ml
Metre	m
Centimetre	cm

Appendix 2

A note on the amount of carbohydrate in the CKD

As described in **STEP 5 (2.1)**, sometimes the amount of carbohydrate calculated for the CKD daily meal plan is tiny. It might only be a few grams, or a 'zero' or 'negative' value may be generated. In particular, this may happen when planning the CKD for an older child or adult, especially when a higher ketogenic ratio is used, e.g. a 4 to 1, in conjunction with a higher body weight and/or lower energy needs associated with reduced mobility.

This situation occurs because the amounts of macronutrients are expressed in ratio to one another, i.e. using the calculation, grams of fat ÷ (grams of protein + grams of carbohydrate). Fat is present in the greatest proportion by weight (to enable ketosis to occur) in relation to the proportion by weight of protein and carbohydrate combined (or added) together. The amount of each macronutrient in the CKD prescription is also influenced by the daily energy requirement and body weight of the individual (**STEP 1**), and their daily protein requirement (**STEP 3**). Examples of this effect are outlined below:

1. With regard to **protein**, it is essential that an adequate quantity is included in the diet. This is of vital importance for growing children. However, for the chosen ketogenic ratio (**STEP 2**) to be achieved, the protein requirement impacts the amount of carbohydrate that can be included in the daily meal plan (**STEP 6**). In the CKD, when calculating the grams of protein and carbohydrate combined, the amount of protein should always take precedence over that from carbohydrate to ensure nutritional requirements are met.
2. The use of a **higher ketogenic ratio**, e.g. 4 to 1, means that the diet is predominantly fat (90% of energy). Therefore, when this ratio is used, proportionally, only a small amount of daily energy needs can be provided by protein and carbohydrate combined (i.e. 10%, Table 1). If the energy needs of the patient are low, a higher ratio diet may also compromise the amount of carbohydrate that can be included in the diet plan in order to meet protein needs.

In practice, a CKD with very little, or no, carbohydrate is potentially unpalatable and may be difficult for a patient to consume orally in conjunction with the requisite high fat intake required. It may also make the creation and preparation of acceptable meals and snacks challenging. However, it may be possible to include some carbohydrate, or increase the amount, in a daily meal plan by careful consideration and adjustment of:

- **Protein:** revising the daily protein requirement by reducing the amount in grams per kg actual body weight can permit the increase or inclusion of carbohydrate in the daily meal plan, e.g. instead of 1.5g protein per kg, it may be feasible to use 1.3g or 1.2g instead, or use the minimum safe levels of protein intake as per WHO⁶ or EFSA⁷ (**STEP 3**).
- **The ketogenic ratio:** lowering this, even slightly, e.g. by 0.5, will reduce the proportion of fat present and allow more carbohydrate to be calculated into the diet plan. The amount of protein can be kept the same, or reduced as above. *However, as this approach may impact dietary efficacy and level of ketosis, careful monitoring is required.*

Only alter protein intake and/or the ketogenic ratio if individual nutritional needs can be adequately met and dietary efficacy achieved.

If none, or only minimal, carbohydrate can be included as part of the CKD prescription, and altering the amount of protein and/or ketogenic ratio compromises nutritional intake or dietary efficacy, this version of the KD may not be suited to the patient because of their unique dietary requirements. In comparison, alternative approaches to implementing the KD, i.e. the MCTKD, LGIT, MAD or MKD, offer greater flexibility with macronutrient and energy intakes, and potentially, improved palatability and acceptability. One of these may be ideal for meeting individual dietary needs more appropriately, particularly those of older children and adults.

For a worked example of altering the protein intake and ketogenic ratio to enable inclusion of carbohydrate, see **Appendix 3**.

Appendix 3

An example of adjusting the amount of protein and ketogenic ratio in a CKD to include carbohydrate for a 17 year old female weighing 45kg, with a daily energy requirement of 1800kcal is shown below. **Table i** is the original calculation that resulted in 0g of carbohydrate daily, and **Table ii** shows how this can be altered to permit 11.5g carbohydrate in her daily meal plan.

Table i: Original CKD calculation, using a chosen protein intake of 1g per kg, and a ketogenic ratio of 4 to 1.

STEP 1	Actual weight: 45kg Estimated daily energy requirement: 1800kcal	
STEP 2	Chosen ketogenic ratio: 4 to 1 (and % of energy from macronutrients, Table 1). Fat, 90%; protein and carbohydrate combined, 10%	
STEP 3	Protein Requirement @ 1g per kg (45 x 1)	= 45g per day
STEP 4	Fat (1800kcal x 90) ÷ 100 1620kcal ÷ 9	= 1620kcal = 180g fat per day
STEP 5	Carbohydrate (1800kcal x 10) ÷ 100 180kcal ÷ 4	= 180kcal = 45g per day (protein and carbohydrate combined)
	Protein (g) and carbohydrate (g) combined per day - daily protein requirement (g) (from STEP 3), i.e. 45g - 45g	= 0g carbohydrate per day

Table ii: Example of the adjustment of the amount of protein and ketogenic ratio (from **Table i**) to allow inclusion of carbohydrate in the daily meal plan.

STEP 1	Actual weight: 45kg Daily energy requirement: 1800kcal	
STEP 2	Reduce the ketogenic ratio*. In this example, from 4 to 1 down to 3.5 to 1 % of energy from macronutrients (Table 1). Fat, 89%; carbohydrate and protein combined, 11%	
STEP 3	Protein Reduce protein from 1g to 0.84g per kg per day, i.e. safe intake level for girls aged 15-18 years ^{7,8} 0.84g x 45kg	= 38g protein per day (rounded up from 37.8g)
STEP 4	Fat (1800kcal x 89) ÷ 100 1602kcal ÷ 9	= 1602kcal = 178g fat per day
STEP 5	Carbohydrate (1800kcal x 11) ÷ 100 198kcal ÷ 4	= 198kcal = 49.5g per day (protein and carbohydrate combined)
	Protein (g) and carbohydrate (g) combined per day - daily protein requirement (g) (from STEP 3), i.e. 49.5g - 38g	= 11.5g carbohydrate per day

N.B. * Changing the ketogenic ratio may affect dietary efficacy and ketosis, and requires regular monitoring.

Appendix 4

Table iii: Example calculation of a transition schedule for the CKD calculated previously in **Tables 4 and 5** using semi-skimmed milk, in combination with meals and snacks in a 3 to 1 ratio.

The incremental increase in ratio and the reduction in grams of carbohydrate and protein, rounded to the nearest 5g, shown, as the amount of milk decreases over the transition period of 6 days. On day 7, the milk is discontinued.

F = Fat; **P** = Protein; **C** = Carbohydrate

Day	Breakfast	Mid am	Lunch	Mid pm	Dinner	Supper	Daily total	Macronutrients from milk per day, to nearest 0.1 g **			Macronutrients from 3 to 1 meals and snacks per day, g ***			Combined totals from milk, meals and snacks per day, g			Increase in ketogenic ratio	Total decrease in P and C from milk, per day, to nearest g
								F	P	C	F	P	C	F	P	C		
	Semi-skimmed milk, g																	
1	100	50	100	50	100	50	450*	7.7	15.3	22.1	145	20	29	153	35.3	51.1	1.8	37
2	85	35	85	35	85	35	360	6.1	12.2	17.6	145	20	29	151	32.2	46.6	1.9	32
3	60	30	60	30	60	30	270	4.6	9.2	13.2	145	20	29	150	29.2	42.2	2.1	22
4	40	20	40	20	40	20	180	3.1	6.1	8.8	145	20	29	148	26.1	37.8	2.3	15
5	20	10	20	10	20	10	90	1.5	3.1	4.4	145	20	29	147	23.1	33.4	2.6	7.5
6	10	5	10	5	10	5	45	8	1.6	2.2	145	20	29	146	21.6	31.2	2.8	2.5
7	0	0	0	0	0	0	0	0	0	0	145	20	29	145	20	29	3.0	0

*Chosen starting volume of semi skimmed milk – 450ml daily.

** Macronutrient content of semi skimmed milk, per 100ml: 1.7g fat, 3.4g protein, 4.9g carbohydrate (UK food values¹⁰).

*** All meals and snacks are given in a 3 to 1 ratio throughout the transition period, providing a total of 1500kcal from 145g fat, 20g protein and 29g carbohydrate daily.



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