An Update on The Science Behind Low-Carbohydrate Diets

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Presented by Jonathan Clinthorne, PhD

Learning Objectives

The goal of todays presentation is to provide an overview of the research that has been performed highlighting the utility of a low-carbohydrate diet for combating obesity, type 2 diabetes, cardiovascular disease, and chronic inflammation.

This training will help you:

Critically appraise research findings related to low-carbohydrate diets.

Apply evidence-based findings to improve the health and nutrition of patients.

Keep abreast of current nutrition and dietetics knowledge and trends.



Centers for Disease Control & Prevention – Updated 2016

Comorbidities

Obesity and overweight are linked to numerous other diseases and health concerns:

- Certain cancers
- Osteoarthritis
- Sleep apnea
- Kidney diseases
- Cardiovascular disease
- Diabetes
- Prediabetes
- Hypertension

In addition, obesity is strongly correlated with the development of metabolic syndrome:

Metabolic syndrome is a defined cluster of cardiometabolic abnormalities that increases an individual's risk of T2DM, coronary heart disease (CHD), and cardiovascular disease (CVD). The core components of MS are glucose intolerance or diabetes, obesity, hypertension, and dyslipidemia specifically hyper-triglyceridemia and low levels of high-density lipoprotein cholesterol (HDL-C).

The Solution(s)

Dietary strategies with clinical efficacy for weight-loss





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Dietary strategies with clinical efficacy for weight-loss





Beyond Genetics



Center for Disease Control

Macronutrient Distribution



Have Americans been following the U.S. Dietary Guidelines (55% calories from carbohydrate and <30% calories from fat)?

An analysis of the last 50 years of data from the National Health and Nutrition Examination Survey (NHANES) shows that American's *have attempted to follow the U.S. Dietary Guidelines* despite a worsening of the obesity epidemic.

Fat Carbohydrate *protein intake has remained relatively stable over this period

Adapted from Cohen 2015 Nutrition

Macronutrient Distribution





Conclusion: The increase in calories during the obesity epidemic was due largely to carbohydrate intake.

Adapted from Ford 2015 Am J Clin Nutr

Nuances

Looking at sources of the increase in carbohydrates in the American diet it becomes quite clear that in many cases fat calories were replaced with calories from refined, high glycemic index, carbohydrates.



Change in total carbohydrate consumption (•) and the percentage of carbohydrate from fiber (vertical bars) in the United States between 1909 and 1997

The dramatic increase in high glycemic index carbohydrates requires increased utilization of insulin in order to properly metabolize and store carbohydrate.

Bodnaruk 2016 Nutr Metab, Chearskul 2008 Am J Clin Nutr, Gross LS 2004 Am J Clin Nutr

Blood Glucose and Insulin Refresher

Humans typically have 1-2 teaspoons of glucose circulating in their bloodstream. Thus even small amounts of dietary carbohydrate represent a substantial physiological stimulus.

When blood glucose levels rise above normal, pancreatic beta-cells secrete insulin.

Insulin instructs muscle, fat, and adipose to take up excess glucose and store it.



Blood Glucose and Insulin Refresher

When insulin levels remain low, hormone sensitive lipase is able to release fatty acids into the blood stream to use as fuel for active tissues such as muscle.

Shuts down hepatic ketone formation, gluconeogenesis, and glycogenolysis in both the liver and muscle.
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Low-Carbohydrate Diets



What is a low-carbohydrate diet?

The American Diabetes Association defines a low-carbohydrate diet as a diet that contains <130 grams of carbohydrate per day (including 25-30 grams of fiber).

The Academy of Nutrition and Dietetics define low carbohydrate diets as ≤ 35% of energy from carbohydrate

In the scientific literature, low-carbohydrate diets range from <20 grams of carbohydrate per day up to ~150 grams per day.

Popular lowcarbohydrate diets

Atkin's Diet South Beach Diet Ketogenic Diet Paleo/primal Diet Low-carb Mediterranean Diet High Fat DASH Diet Whole30 Diet

When carbohydrate is restricted, calories are replaced with fat and/or protein.

Why Low-Carbohydrate Diets?

Low-carbohydrate diets seek to minimize insulin secretion in the pancreas and thus reduce the influence of insulin on fuel partitioning.

- Allowing increased utilization of fatty acids as a fuel source.
- Ketone bodies are produced from fatty acids in order to satisfy the brain's energy requirements.

By focusing on low glycemic impact of foods and reducing insulin usage, blood sugar levels tend to remain more stable, providing sustained energy and fewer episodes of fatigue and cravings related to low-blood sugar levels.



Low-Carbohydrate Diets and Weight-Loss

An initial concern with promoting lowcarbohydrate, higher-fat diets for weight loss was that because fat provides more calories per gram, participants would overconsume calories and gain weight.

However, many studies use an "ad-libitum" feeding protocol for the low-carbohydrate group and see that these diets do not result in weight-gain.

This is likely due to the fact that low-carbohydrate diets either directly result in the release of satiety signals from the gut or metabolites produced from low-carbohydrate diets themselves suppress appetite.

Bodnaruk 2016 Nutr Metab, Chearskul 2008 Am J Clin Nutr

- Fat slows gastric emptying, stimulates secretion of CCK and PYY.
- Dietary protein, short-chain fatty acids, and free fatty acids increases GLP-1 production from enteroendocrine cells.
- 3. BCAAs act on the hypothalamus to reduce appetite.
- Ketone bodies such as betahydroxybutyrate also appear to have appetite suppressive effects.

Low-Carbohydrate Diets and Appetite



In a randomized controlled trial (RCT), McClernon et al. demonstrated that people following a low-carbohydrate diet have a lower hunger score than those following a low-fat diet. In a separate RCT, it was demonstrated that cravings restricting carbohydrates actually decreases cravings and preferences for highcarbohydrate foods.

Conclusion: Carbohydrate restriction does not result in carbohydrate cravings over a 2-year period.



Adapted from: McClernon 2007 Obesity, Martin 2011 Obesity

Clinical Evidence

Annals of Internal Medicine

Original Research

Effects of Low-Carbohydrate and Low-Fat Diets A Randomized Trial Ivdia A. Bazzano, M.D. PhD, MPH*: Tian Hu, MD, MS*: Kristi Revnolds, PhD: Lu Yao, MD, MS: Calvon Bunol, MS, RD, IDN: Yanxi Liu, MS Chung-Shiuan Chen, MS; Michael J. Kiag, MD, MPH; Paul K. Whelton, MD, MSc, MB; and Jiang He, MD, PhD

Participants with a BMI of between 30-45 kg/m² who were free of metabolic or cardiovascular disease were randomized to either a lowcarbohydrate or low-fat diet and followed for 1 year. There were no differences between groups in body weight, diet, or fat mass after randomization.

Carbohydrate intake was instructed to be <40 g/d for the low-carbohydrate group whereas the low-fat group was allowed 55% energy from carbohydrate, but instructed to restrict calories from fat. Neither diet included specific calorie goals.

Adapted from Bazzano 2014 Ann Intern Med

	3 months			6 months			12 months		
	Low Fat	Low CHO	Between Group P value	Low Fat	Low CHO	Between Group P value	Low Fat	Low CHO	Between Group P value
Energy, kcal	1418	1258	NA	1481	1324	NA	1527	1448	NA
Carbohydrate, g	193	97	NA	202	93	NA	198	127	NA
Body weight, kg	-2.6	-5.7	<0.001	-2.3	-5.6	<0.001	-1.8	-5.3	0.002
Fat mass (%)	-0.3	-1.1	0.066	-0.1	-1.1	0.011	+0.3	-1.2	0.011
Lean mass (%)	0.4	1.6	0.010	0.2	1.5	0.002	-0.4	1.3	0.002

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The low-carbohydrate diet resulted in weight loss of 5.3 kg and also produced a significant loss in fat mass after 1 year while maintaining lean mass.

In the low-fat group participants ended up losing 1.8 kg and ended the study gaining 0.3% in fat mass and losing 0.4% in lean mass.

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Adapted from Bazzano 2014 Ann Intern Med

Clinical Evidence

In a RCT published in JAMA in 2018, Gardner et al. compared the effects of a low-fat (LF) versus a low-carbohydrate (LC) diet in the DIETFIT study on 12-month weight loss in overweight adults.

Participants in both groups lost a significant amount of weight, though not statistically significant between groups (-5.29 kg in LF vs. -5.99 kg in LC).

Study participants received extensive coaching on how to effectively create healthy low-fat and low-carbohydrate diets from RDs.



Conclusion: RDs serve as an important resource for nutrition coaching in a weight-loss setting, and helping coach clients to follow either a low-fat diet or a low-carbohydrate diet can help support weight-loss goals in overweight and obese individuals.

Gardner 2018 JAMA

Meta-Analysis

British Journal of Nutrition (2016), 115, 466-479 © The Authors 2015 doi:10.1017/S0007114515004699

Effects of low-carbohydrate diets v. low-fat diets on body weight and cardiovascular risk factors: a meta-analysis of randomised controlled trials

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A meta-analysis of 11 RCTs of 6 months or longer with 1369 participants comparing lowcarbohydrate (LC) diets (<20% of energy) and low-fat (LF) diets on weight loss and risk factors of cardiovascular disease.

"Compared with participants on LF diets, participants on LC diets experienced a greater reduction in body weight (-2.17 kg; 95% CI -3.36, -0.99) and TAGs (-.26mmol/l; 95% CI -0.37, -0.15), but a greater increase in HDL-cholesterol (0.14mmol/l; 95% CI 0.09, 0.19) and LDLcholesterol (0.16mmol/l; 95% CI 0.003, 0.33)." – Mansoor et al. 2016

Mansoor 2016 Br J Nutr

More Than Just Weight-Loss

At a glance, low-carbohydrate diets may just appear as another method for decreasing overall caloric intake, and their beneficial effects compared to low-fat diets may simply be due to the fact that study participants lose more weight.

However, recent literature is emerging, suggesting that carbohydrate restriction might elicit beneficial alterations in hormonal, enzymatic, and mitochondrial expression.

Some studies have compared isocaloric low-carbohydrate diets and low-fat diets and observed unique outcomes.

More Than Just Weight-Loss



Using an isocaloric approach designed not to cause weight-loss in a group of type II diabetics, Gannon et al. demonstrated beneficial effects of restricting carbohydrate to account for <20% of energy on the % of glycated HbA1c.

Given that HbA1c truly takes 3 months to turn over, this change over the short term indicates there may be additional reductions in glycated HbA1c levels at 12 weeks.

Adapted from Gannon 2006 Nutr Metab

Recent data indicates 52% of the American population is either diabetic or prediabetic. The cost of diabetes is estimated to be over \$320 billion annually.

Reducing the glycemic load of the diet is a universally accepted paradigm for combatting type II diabetes.

Reducing the amount of carbohydrate in the diet significantly reduces the glycemic load of the diet. A well formulated low-carbohydrate diet contains only low-GL carbohydrate sources.



Menke 2015 JAMA, American Diabetes Association

As diabetes is a disease of impaired carbohydrate metabolism, it is natural that carbohydrate restriction should be an efficacious treatment. In fact, independent of the effect of low-fat diets in healthy people, in people who are insulin-resistant, emphasizing carbohydrates may be the opposite of good advice.



Petersen, *et al.* showed that ingestion of a high carbohydrate meal led to a >2x greater increase in *de novo* fatty acid synthesis and hepatic triglyceride formation **in insulin-resistant men compared to a similar group of insulin-sensitive controls**.

Petersen 2007 Proc Natl Acad Sci

Because of the plethora of RCTs investigating low-carbohydrate diets vs. low-fat diets for management of type II diabetes, numerous meta-analyses have been performed.



Both the carbohydrate-restricted and low-fat diets were able to produce clinically meaningful HbA1c reductions of ≥0.5%, yet low-carbohydrate diets produce a greater reduction of up to 0.19% over six months.

Upon subgroup analysis a low-carbohydrate prescription (< 26% of energy) produces the greatest reductions in HbA1c, while restricting carbohydrate to 26-45% of total energy provides no additional benefits over low-fat diets.

Snorgaard 2017 BMJ Open Diabetes Res Care

People with diagnosed diabetes, on average, have medical expenditures approximately 2.3 times higher than what expenditures would be in the absence of diabetes.

"There was a greater reduction in medication use for participants on carbohydrate-restricted diets compared with high carbohydrate diets at every time point. Carbohydrate restriction either reduced the dosage of oral medications and/or insulin, or saw an elimination of medication for participants across all studies that reported on medication outcomes." – Sainsbury 2018

American Diabetes Association, Sainsbury 2018 Diabetes Res Clin Pract

In 2013 Ajala et al. performed a systematic review and meta-analysis of 20 RCTs comprising 3073 individuals, comparing several different dietary philosophies and their effectiveness for treating T2DM. Study duration ranged from 6 months to 4 years.

Conclusion:

Low-carbohydrate diets are as effective as lowglycemic index, Mediterranean, and high protein diets in improving various markers of glycemic control and reducing cardiovascular risk in people with diabetes.

Low-carbohydrate approaches **should be considered in the overall strategy** of diabetes management.

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Conclusion:

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Low-carbohydrate approaches **should be considered in the overall strategy** of diabetes management. Studies of up to 44 months in length have demonstrated the safety and efficacy of lowcarbohydrate diets in type II diabetics.

Nielsen 2008 Nutr Metab

T2DM and Cardiovascular Disease

Not surprisingly, type 2 diabetics have an increased risk of developing cardiovascular disease.

People with type 2 diabetes who lose at least 10% of their initial body weight reduce CVD end points by 21%.

Adults with diabetes are two to four times more likely to die from heart disease than adults without diabetes.

Indeed, T2DM is associated with atherogenic dyslipidemia, characterized by high triglycerides, elevated small dense LDL-C and low HDL-C.

www.heart.org

Does a Low-Carbohydrate Intake Increase Cardiovascular Disease Risk?

Studies show that low-carbohydrate diets influence numerous cardiometabolic markers, suggesting they can significantly impact cardiovascular health.

Cardiometabolic marker's and their response to low-carbohydrate diets

Lipoproteins

HDL ↑ Any LDL increases tend to be large buoyant LDL Small dense LDL – No change

> "In contrast, we and others have shown that higher carbohydrate intake promotes selective increases in levels of small LDL particles." - Chiu 2017

Triglycerides

"The most consistent and predictable lipid change with consumption of a [very low carbohydrate diet] is a reduction in TAG. The most dramatic reductions are seen in those with moderate hypertriglyceridemia." – Volek 2005

"There is probably no dietary outcome as reliable as the reduction in TG due to carbohydrate restriction." – Accurso 2008

A 2012 meta-analysis of 19 randomized controlled trials by *Santos et al.* showed a global decrease in triglyceride levels of 29.71 mg/dL (95% CI -31.99/-27.44).

Framingham Risk Score

The **Framingham Risk Score** is a genderspecific algorithm used to estimate the 10year cardiovascular risk. The score was first developed based on data obtained from the Framingham Heart Study, to estimate the 10year risk of developing coronary heart disease.

"...in our study, participants randomly assigned to the low-carbohydrate diet had greater decreases in 10-year CHD risk score than those assigned to the low-fat diet." – Bazzano 2014

What About Saturated Fat?

It's important to distinguish between saturated fat that is consumed (<u>dietary saturated</u> <u>fat</u>) versus saturated fat in the body (<u>circulating levels of</u> <u>saturated fat</u>). There is absolutely a consistent pattern of disease risk associated with increased <u>circulating</u> levels of saturated fatty acids while levels of dietary saturated fatty acids seem to have a much weaker association.

People with higher levels of serum saturated fat have increased risk of developing metabolic syndrome, diabetes, heart attack, and heart failure.

This raises two important questions:

- 1. What causes increased level of saturated fat in the blood?
- 2. Does eating saturated fat in the context of a low-carbohydrate diet increase circulating saturated fatty acids?

What About Saturated Fat?

Dietary intake of saturated fats and serum levels of saturated fat show virtually no correlation <u>in</u> <u>the presence of carbohydrate restriction.</u>

This has been repeatedly demonstrated:

In one RCT, overweight men and women consumed diets for 12 weeks containing ~1500 kcal/day that were either very low carbohydrate or low fat.

Despite consuming a 3-fold higher dietary SFA intake than the low fat group (36 vs 12 g/day), the low carbohydrate diet group had a significantly greater reduction in the proportion and absolute amounts of circulating saturated fat.

A similar RCT was performed using eucaloric diets designed to prevent weight-loss. This study reported similar outcomes in the absence of weight loss.



Forsythe 2008 Lipids, Forsythe 2010 Lipids

V	Vhat A	bou	t Sat	curat	ed F	at?	۲	RESEARCH ARTICLE Effects of S Carbohydra Fatty Acids with Metab Brittanie M. Volk ¹ , Lau Catherine Seare ¹ , Jua Richard S. Bruno ⁵ , Ca Jeff S. Volek ^{1,3}	tep-Wise Increases in Dietary te on Circulating Saturated and Palmitoleic Acid in Adults olic Syndrome rr J. Kunces', Daniel J. Freidenreich', Brian R. Kupchak', n C. Artistizabal' ² , Maria Luz Fernandez ² , rt M. Maresh', William J. Kraemer', Stephen D. Phinney ⁴ .
In a fatty	In a third study, <i>Volk et al.</i> examined the influence of step-wise increases of carbohydrate intake on circulating fatty acids and palmitoleic acid in adults with metabolic syndrome. Whole grain and low-GI carbohydrates were emphasized and energy levels were kept constant.								
		[Controlled	d Feeding P	Periods (3 w	veeks each)		٦	Circulating myristic acid levels rise as
	Free-Living	C1 47 g CHO/d 84 g SFA/d	C2 83 g CHO/d 76 g SFA/d	C3 131 g CHO/d 71 g SFA/d	C4 179 g CHO/d 61 g SFA/d	C5 251 g CHO/d 49 g SFA/d	C6 346 g CHO/d 32 g SFA/d		carbohydrate intake increases.
Triglyceride (v	vt%)							ANOVA	thought to be a primary
14:0	1.02 ± 0.3	0.99 ± 0.38	1.09 ± 0.33	1.28 ± 0.44	1.27 ± 0.75	1.62 ± 0.89	1.79 ± 0.89	0.000	marker of carbohydrate disposal via <i>de novo</i>
16:1	2.92 ± 0.61	2.59 ± 0.58	2.79 ± 0.58	3.15 ± 0.92	3.09 ± 1.03	3.61 ± 1.22	3.89 ± 1.26	0.000	lipogenesis.
SFA	29.72 ± 2.54 Carbohvdrate	29.82 ± 1.83	29.45 ± 1.24	29.95 ± 2.24	30.43 ± 4.50	31.19 ± 4.69	31.38 ± 5.31	0.294	SFA levels did not decline as amounts of dietary SFAs went
	4							Saturated f	at down.

Adapted from Volk 2014 PLoS One

What About Saturated Fat?

Saturated fat is also suggested to be restricted due to its ability to raise LDLcholesterol, however this ignores several key points:

- Not all saturated fats raise LDL-C to the same extent, the potency of the LDL-raising effects of individual SFAs are as follows: lauric acid (C12:0) > myristic acid (C14:0) > palmitic acid (C16:0).
 - $\circ~$ Stearic acid (C18:0) generally has a neutral effect on lipid and lipoprotein profiles.
- 2. Lauric acid relative to other SFAs increases HDL-C significantly and thereby reduces the total cholesterol (TC):HDL-C ratio.
- 3. Foods like meat, butter, cheese, poultry and fish are primarily palmitic and stearic acid.
 - 1. Intake of odd chain SFAs from full-fat dairy has been correlated with reduced risk of CVD.
- 4. Increased intake of total saturated fatty acids, particularly myristic (14:0) and palmitic (16:0) acids, correlated with increased plasma levels of larger LDL particles, but not with changes in smaller LDL.
- 5. The effects of SFAs on CVD risk factors and CVD clinical endpoints are intrinsically modulated by the nutrients that replace them.
- 6. Small dense LDL particles have been shown to be reduced with lower carbohydrate intake, regardless of the level of saturated fatty acid intake.



Nuances to LDL Cholesterol

The oversimplification that LDL cholesterol is "bad" has resulted in confusion about the effect of diet on serum lipoprotein levels and cardiovascular health.

A large body of research suggests large LDL particles are less atherogenic than small dense LDL particles. Dietary carbohydrate and dietary fats influence subclasses of LDL in a different fashion.

Heart disease patients often have increased small dense LDL, Apo-B containing lipoprotein remnants, and decreased HDL.

Adapted from Siri-Tarino 2015 Ann Rev Nutr

Carbohydrate and Small Dense LDL

In vivo, small LDL has a longer residence time in plasma than large LDL. Small, dense LDL is depleted of vitamin E and is more rapidly oxidized *in vitro*, characteristics that could make small LDL more atherogenic.



 The prevalence of LDL pattern B (a marker defined by the predominance of sdLDL), has been linearly and positively associated with increasing concentrations of dietary CHOs in RCTs.

Because detailed lipoprotein analysis is rarely performed during routine blood work, an alternative is to use other biomarkers of cardiovascular disease to asses dietary impacts. Other predictive markers that may be more predictive: TC:HDL, TAG:HDL, CRP, Non-HDL Cholesterol, Low-HDL.

Metabolic Syndrome



Contents lists available at ScienceDirect Progress in Lipid Research journal homepage: www.elsevier.com/locate/plipres

Progress in Lipid Research 47 (2008) 307-318

Review

Dietary carbohydrate restriction induces a unique metabolic state positively affecting atherogenic dyslipidemia, fatty acid partitioning, and metabolic syndrome Jeff S. Volek^{a,*}, Maria Luz Fernandez^b, Richard D. Feinman^c, Stephen D. Phinney^d

Conclusion: Low carbohydrate diets are effective for global improvement in markers associated with metabolic syndrome.

Inflammation



Adapted from Forsythe 2008 Lipids

How to Maintain Adequate Fiber Intake on a Low Carbohydrate Diet

Start with a foundation of 6-8 servings of non-starchy, fiberrich vegetables (~15 grams of net carbs per day).

Each meal should contain a 4-6 ounce serving of protein.

Include additional calories from added fats. Nuts and seeds can provide additional fiber.

Depending on weight loss and health goals, low glycemic carbohydrates found in whole grains and fruit can be used to provide additional fiber.

A Day of Low Carbohydrate Eating



A Day of Low Carbohydrate Eating

Replacing high-starch carbohydrates with fiber-rich carbohydrate sources and vegetables can help increase both the fiber intake and vegetable intake of those following a low-carbohydrate diet.

- Cauliflower "rice"
- Spiralized vegetable noodles
- Cucumber bites
- Romaine lettuce wraps
- Vegetable crudité and dip
- Roasted seasoned chickpeas
- Turnip fries
- Green smoothies
- Eggplant lasagna



Diet and Weight Regain

According to data from the National Health and Nutrition Examination Survey (1999-2006), only 1 in 6 overweight or obese adults report ever having maintained weight loss of at least 10% for 1 year.

One explanation for the poor long-term outcomes of weight-loss diets relates to behavior—that people simply fall back into bad habits and overconsume. However, an alternative explanation is that weight loss results in a decline in metabolism (energy expenditure), making weight maintenance difficult to maintain.

Can certain eating patterns influence metabolism, potentially off-setting weightloss induced declines in energy expenditure?

Diet and Weight Regain

In an elegant study, from David Ludwig's lab, the effects dietary composition during weight loss maintenance were assessed in a three-way cross-over design.

After achieving 10 to 15% weight loss on a run-in diet, participants consumed low-fat (60% of energy from carbohydrate, 20% fat, 20% protein; high glycemic load), low-glycemic index (40%-40%-20%; moderate glycemic load), and very-low-carbohydrate (10%-60%-30%; low glycemic load) diets in random order, each for 4 weeks.

Total energy expenditure (TEE) was measured before weight loss and after each maintenance diet to determine the influence of macronutrients on energy expenditure.

Study Design



Resting energy expenditure, total energy expenditure, serum lipids and metabolic hormones were all measured pre-weight loss and during each dietary intervention.

Ebbling 2012 JAMA

Diet and Weight Regain

The decrease in TEE was assessed using doubly-labelled water were found to differ significantly by diet from baseline.

Low fat: -423 kcal/day Low glycemic index: -297 kcal/day Low carbohydrate: -97 kcal/day Overall P = 0.003

TEE differed by about 300 kcal/d between low fat and low carbohydrate diets, an effect corresponding to the amount of energy typically expended in 1 hour of moderateintensity physical activity.



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Diet and Weight Gain

Food	Increase in GL (Kg change per 1 serving)	Minimal change in GL (Kg change per 1 serving)	Decrease in GL (Kg change per 1 serving)
Red Meat *	1.1 ± 0.5	1.0 ± 0.5	0.75 ± 0.35
Processed meats *	1.1 ± 0.5	0.95 ± 0.6	0.25 ± 0.2
Poultry	0 ± 0.4	-0.1 ± 0.25	-0.25 ± 0.15
Seafood	-0.5 ± 0.4	-0.7 ±0.35	-1.0 ± 0.3
Eggs *	0.25 ± 0.2	0.15 ± 0.2	-0.8 ± 0.3
Legumes *	-0.15 ± 0.15	-0.3 ± 0.2	-0.6 ± 0.2
Butter	0.1 ± 0.05	0.1 ± 0.1	0.08 ± 0.04
Nuts *	-0.15 ± 0.1	-0.3 ± 0.1	-0.7 ± 0.1
Yogurt	-0.7 ± 0.05	-0.7 ± 0.1	-0.75 ± 0.11
Cheese *	0.1 ± 0.05	0.025 ± 0.1	-0.3 ± 0.075
Whole milk	-0.075 ± 0.1	-0.1 ± 0.15	-0.075 ± 0.125
Low-fat milk	-0.02 ± 0.01	-0.03 ± 0.02	0.02 ± 0.01

Smith et al. included data from:

- The Nurses' Health Study (NHS; n = 121,701 female registered nurses enrolled in 1976)
- The Nurses' Health Study II (NHS II; n = 116,686 younger female registered nurses enrolled in 1989)
- The Health Professionals Follow-Up Study (HPFS; n = 51,529 male health professionals enrolled in 1986).

Their data indicates that increasing protein sources, especially when replacing high glycemic load foods, helps to stave off weight gain over time.

Adapted from Smith 2015 Am J Clin Nutr

A low carbohydrate diet puts participants at risk of ketoacidosis...

Even at the very highest levels of carbohydrate restriction, typically used as a therapeutic tool for epileptic seizures, ketone body levels are around 8 mmol/L, no where near enough to decrease blood pH.

Typical low carbohydrate diets result in blood ketone levels between 1-3 mmol/L.

Blood Levels	Normal Diet	Ketogenic Diet	Diabetic Ketoacidosis
Glucose (mg/dL)	80-120	65-80	>300
Insulin (μU/L)	6-23	5.5-9.4	~0
Ketone Body (mmol/L)	0.1	1-8	>25
рН	7.4	7.4	<7.3

Low carbohydrate diets ignore the principle of moderation and result in a nutrient-deficient diet...

Even at the lower end of the carbohydrate spectrum you can still get all of the essential nutrients and energy your body needs by selecting from a broad array of natural low carbohydrate foods. This includes a wide range of vegetables and fruits, including raspberries, strawberries, blueberries, tomatoes, olives and avocados, plain Greek yogurt, nuts/seeds and their butters -- all of which are relatively low in carbohydrate and packed with nutrients.

In a recent publication, Zinn et al. demonstrated that "despite macronutrient proportions not aligning with current national dietary guidelines, a well-planned LCHF meal plan can be considered micronutrient replete."

Zinn 2018 BMJ Open

The majority of weight loss comes from water and lean body mass...

In head-to-head comparisons in studies lasting more than a few weeks, low carbohydrate diets consistently outperforms other diets in terms of fat loss. The majority of studies indicate that when carbohydrates are reduced, there is a greater percentage of fat loss and better retention of lean body mass. It is true that the first few days of a low carbohydrate diet may increase water loss, which is why drinking plenty of water and ensuring adequate electrolyte intake (sodium, potassium, magnesium) is important.



Low carbohydrate diets are only a fad diet for short-term weight loss...

While many patients experience rapid weight loss when carbohydrates are initially restricted, due to many factors, people tend to resume their previous unhealthy diet and regain weight.

When examining low-term research comparing low-fat and low-carbohydrate diets, you can see that many people in the low-carbohydrate arm, eventually increase their carbohydrate intakes above 130 grams per day, likely above their carbohydrate tolerance. With greater acceptance of lowcarbohydrate diets and the awareness of their efficacy by the medical community, dietitians can be leaders in providing support and coaching for clients in how to successfully implement and maintain a healthy lowcarbohydrate diet.

Review

- 1. Low carbohydrate diets are a viable and effective option for weight-loss. RCTs consistently demonstrate that lowcarbohydrate diets are more effective than low-fat diets for weight-loss in the first 6 months. Study participants also tend to maintain more lean mass and lose more fat mass. This has been confirmed in large-scale metaanalyses.
- 2. Diabetes is a disease of impaired carbohydrate metabolism, restricting carbohydrates is an effective strategy for improving diabetes outcomes. Studies consistently show a reduced need for medication in type II diabetics who follow low-carbohydrate diets.
- 3. Many of the biomarkers used for assessing cardiovascular disease risk are also modified by a well-formulated lowcarbohydrate diet. "There is probably no dietary outcomes as reliable as the reduction in triglyceride due to carbohydrate restriction." – Volek 2005
- 4. In the context of a low-carbohydrate diet, dietary saturated fat does not appear to raise serum levels of saturated fatty acids. Dietary carbohydrates and SFAs affect different components of lipoprotein metabolic pathways, with differential production of LDL particles of varying size and quality, and associations with CVD risk.
- 5. A healthy low-carbohydrate diet is built on a foundation of non-starchy, fiber-rich vegetables, healthy fats, and moderate amounts of protein. Carbohydrate levels can be slowly increased until weight-loss slows or stops and a person has found their carbohydrate tolerance.