Micronutrient Absorption and Interactions After Bariatric Surgery

Taylor A. Brodie, MS, RDN, LD
March 23rd 2023

Disclosures

- Employee of Celebrate Vitamins

Objectives

- Review physiological changes influencing micronutrient metabolism after metabolic and bariatric surgery (MBS)
- Reevaluate nutrient-nutrient interactions
- Explore the nutrigenomic and nutrigenetic influences on micronutrient metabolism

Introduction

- Micronutrient deficiencies are high among patients with obesity.
- Micronutrient deficiencies are high among patients who have had MBS.

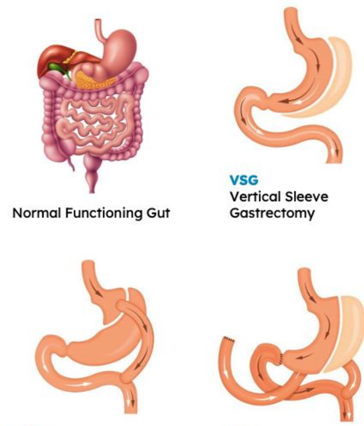
Nutrient	**Deficiency prevalence in those with obesity (pre-op surgical and nonsurgical)**	**Deficiency prevalence in those who have had MBS (varies by procedure)**
Vitamin D	As high as 90%	As high as 100%
Iron	14-45%	14-62%
Thiamin	15-29%	As high as 45%
Vitamin B12	2-18%	4-20%
Folate	2-54%	As high as 65%
Vitamin A	7-14%	As high as 70%
Vitamin E	2.2%	0-65%
Zinc	28-74%	19-70%
Copper	As high as 70%	0-90%

Parrot et al. *SOARD.* 2017; 13(5). 10.1016/j.soard.2016.12.018
Kaidar-Person et al.*Obes Surg*, 2008; 18(7). 10.1007/s11695-007-9349-y
Kaidar-person et al. *Obes Surg*, 2008; 18(8). 10.1007/s11695-007-9349-y
Isom & Majumdar, eds. *Pocket Guide to Bariatric Surgery.* 2022.

Introduction Cont.

Different Procedures → Different Anatomy → Different Impact on Micronutrient Status

- Size of the gastric pouch
- Resection of antrum
- Length of bypassed intestine
- Length of the common channel
- Gastric emptying and transit time



ASMBS Guidelines

Guidance for baseline micronutrient needs after surgery for majority of patients

ELSEVIER
Surgery for Obesity and Related Diseases 16 (2020) 175–247
SURGERY FOR OBESITY AND RELATED DISEASES

Guidelines

Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures – 2019 update: cosponsored by American Association of Clinical Endocrinologists/American College of Endocrinology, The Obesity Society, American Society for Metabolic & Bariatric Surgery, Obesity Medicine Association, and American Society of Anesthesiologists

Jeffrey I. Mechanick, M.D., F.A.C.P., F.A.C.N., M.A.C.E.[a,b,*], Caroline Apovian, M.D.[c], Stacy Brethauer, M.D.[d], W. Timothy Garvey, M.D., F.A.C.E.[e,f], Aaron M. Joffe, D.O., F.C.C.M.[g], Julie Kim, M.D.[h], Robert F. Kushner, M.D.[i], Richard Lindquist, M.D., F.A.A.S.P.[j], Rachel Pessah-Pollack, M.D., F.A.C.E.[k], Jennifer Seger, M.D.[l], Richard D. Urman, M.B.A., M.D., C.P.E.[m], Stephanie Adams, Ph.D.[n], John B. Cleek, M.D.[e], Riccardo Correa, M.D., F.A.C.E.[o], M. Kathleen Figaro, M.S., M.D., F.A.C.E.[p], Karen Flanders, M.S.N., C.N.P., C.B.N.[q], Jayleen Grams, M.D., Ph.D.[r,s], Daniel L. Hurley, M.D., F.A.C.E.[t], Shanu Kothari, M.D., F.A.C.S., F.A.S.M.B.S.[u], Michael V. Seger, M.D., F.A.C.S., F.A.S.M.B.S.[v], Christopher D. Still, D.O., F.A.C.N., F.A.C.P.[w,x]

Celebrate® Nutritional Supplements

2019 ASMBS Guidelines for RNY

Multivitamin (MVI)	
Thiamin	At least 12 mg / day *
Folic Acid	400 – 800 mcg / day from MVI
	800 – 1,000 mcg / day total (female, child bearing age)
B12	Oral: 350 – 1,000 mcg / day
Vitamin D	3,000 IU (75 mcg)
Vitamin A	5,000 – 10,000 IU (1,500 – 3,000 mcg) / day
Vitamin E	15 mg / day
Vitamin K	90 – 120 mcg / day
Copper	2 mg / day from MVI
Zinc	8 – 22 mg / day from MVI
Zinc to copper ratio: 8 – 15 mg of zinc for every 1 mg of copper	
Iron (from all supplements)	
At least 18 – 60 mg / day **	
CANNOT take with Calcium	
Calcium (from food and supplements)	
1,200 – 1,500 mg / day	
Take in divided doses	
Calcium Citrate may be taken with or without meals	
Other	
Protein (often individualized)	Minimum of 60 g / day with some patients needing higher amounts of 80 – 90 g / day
Fluids (often individualized)	At least 50 oz / day to ensure adequate hydration

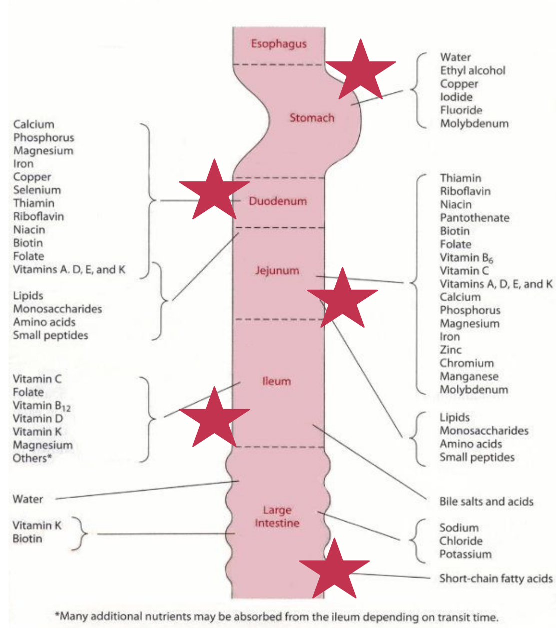
* At risk patients: rapid weight loss, protracted vomiting, the need for parenteral nutrition, excessive alcohol, neuropathy, encephalopathy, and/or heart failure. At risk patients need at least 50 – 100 mg of thiamin daily.

** Low risk patients (males and patients without a history of anemia) need 18 mg of iron from their multivitamin. Higher risk patients (menstruating females who have had SG, RNY, or BPD / DS or those with anemia) need at least 45-60 mg of iron daily.

Information adopted from Mechanick et al SOARD. 2020; 16:175-247

Absorption Considerations

- Loss of Absorption Site
- Nutrient Status & Absorption
- Dose-Dependent Absorption
- Competitive Transporters
- Enteroplasticity
- Absorption in Large Intestine
- Nutrient-Nutrient Interactions
- Genetic Considerations



Courtesy: *Advanced Nutrition and Human Metabolism, fifth edition.*

Nutrient Status and Absorption

- Homeostasis Mechanisms
  - Feedback mechanism meant to increase absorption during low concentrations and decrease absorption to avoid toxicity
- Transporter number, efficiency and/or gene expression is altered based on concentration
  - Iron - hepcidin*
  - Copper - hCtr1

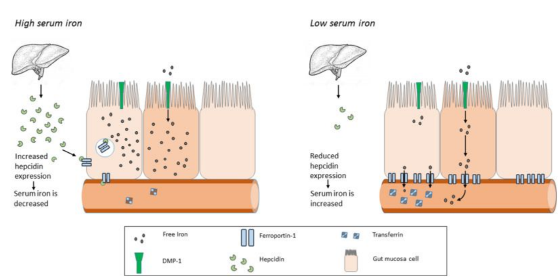


Image from Cornelissen et al EBioMedicine. 2019;47. doi: 10.1016/j.ebiom.2019.08.014.

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Tapiero et al. *Biomed Pharmacother.* 2003; 57(9). doi: 10.1016/s0753-3322(03)00012-x
Cornelissen et al. *EBioMedicine.* 2019;47. doi: 10.1016/j.ebiom.2019.08.014.

Dose-Dependent Absorption

01	Inverse relationship between dose and absorption	• Vitamin B12 • Pantothenic Acid • Vitamin C • Vitamin E • Copper • Magnesium
02	Absorption rate decreases after saturation threshold	• Calcium - 400-500mg • Magnesium - 500mg • Vitamin B12 (IF Threshold 1-2mcg) • Riboflavin - 27mg
03	Alters transporter transcription	• Zinc - ZIP4 • Biotin - SMVT • Thiamin - ThTr2

Gropper et al. Advanced Nutrition and Human Metabolism. 7th Edition. 2008
Kaidar-person et al. *Obes Surg*, 2008; 18(8). doi:10.1007/s11695-007-9349-y
Said HM. *Biochemical Journal*. 2011;437(3). doi:10.1042/BJ20110326
NIH ODS. Health Professionals Fact Sheet. Riboflavin.
NIH ODS. Health Professionals Fact Sheet. Vitamin B12

Competitive Transporters

DMT1 - Divalent Metal Transporter 1

- Thought to also transport various other metal cations
  - Cadmium: lettuce, spaghetti, bread, potatoes
  - Preference for Fe(2+)
  - Other Minerals: Copper, Manganese, and Zinc
- Also influenced by hepcidin concentrations

SMVT - Sodium Dependent Micronutrient Transporter

- Biotin
- Pantothenic Acid
- Iodide

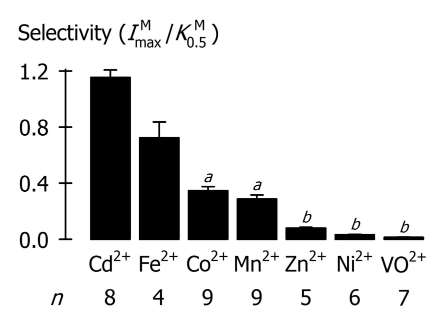


Figure from Shawki et al., *Curr Top Membr.*, 2012; 70. DOI: 10.1016/B978-0-12-394316-3.00005-3

Shawki et al. *Curr Top Membr.* 2012;70. doi: 10.1016/B978-0-12-394316-3.00005-3.
Lefebvre et al. *Nutrients*. 2021;13(8):2516. doi: 10.3390/nu13082516.

Enteroplasticity

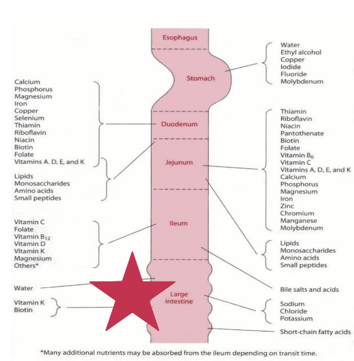
- Changes in Morphology
  - The adaptation of gastrointestinal cell to change structure and function in response to stimuli. This could be changes in the following:
    - Proliferation
    - Villus Height
    - Crypt Depth
    - Mucosal Surface Area
    - Intestinal Weight
- RNY:
  - Rodent models have seen roux-limb and common channels with increased bowel width, villus height, crypt depth, and cell proliferation. In contrast, the biliopancreatic limb only increased bowel length.
  - In humans, roux-limb enterocytes caused hypertrophy with increased cell proliferation and crypt depth.

Seeley et al. *Cell Metab.* 2015;21(3). Doi: 10.1016/j.cmet.2015.01.001.
Camastra et al. *Eat Weight Disord.* 2022;27(2). Doi: 10.1007/s40519-021-01194-5.

Bacterial Fermentation of Nutrients

The following nutrients are thought to be produced by microorganisms in the large intestine:

- **Vitamin K**
- **Biotin**
- Folate
- Riboflavin
- Pantothenic Acid



Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.

Colonic Absorption - Vitamins

Nutrient	Notes
Thiamin Diphosphate (TDP)	Energy-dependent transport.
Riboflavin	Smaller doses absorbed by Riboflavin Vitamin Transporters (RFVT) 1 and 3
Nicotinic Acid	Absorbed via high affinity carriers
Pantothenic Acid	Bacteria produced pantothenic acid is absorbed via shared multivitamin transporter (SMVT)
Folate	Absorbed via active transport with Bidirectional Reduced Folate Carrier
Biotin	Carrier-mediate enzymes absorb biotin and providing nutritional value
*Vitamin K (Menaquinones)	Passively diffused after produced by certain colonic bacteria and providing nutritional value

*With the exception of biotin and Vitamin K, it is unclear how colonic absorption influences nutrient status

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Said HM. *Biochemical Journal.* 2011;437(3). doi:10.1042/BJ20110326

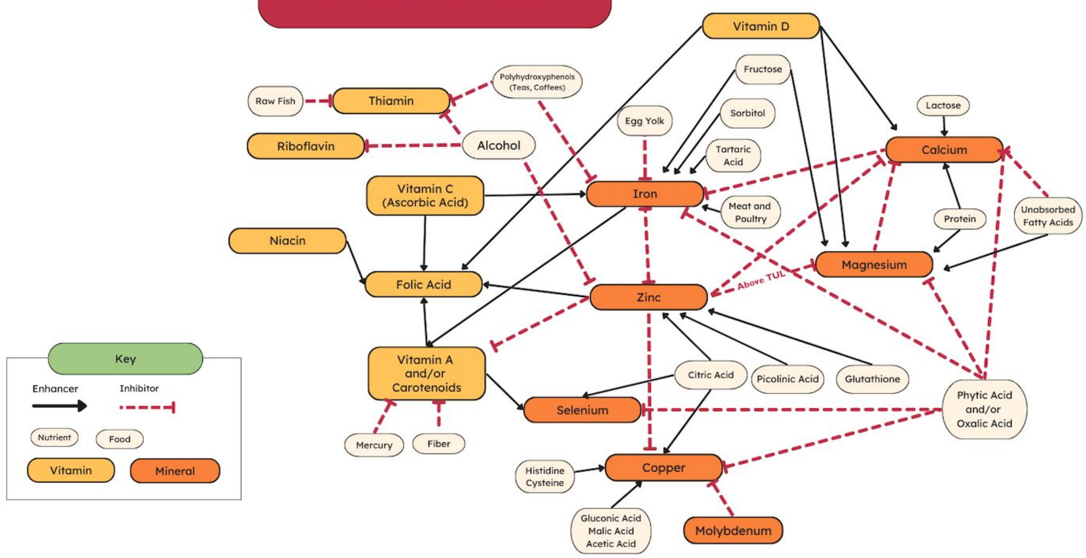
Colonic Absorption - Minerals

Nutrient	Notes
Calcium	Microbiota separates calcium bound to fermentable fiber. May contribute 4-10% of total dietary calcium absorption
Magnesium	Absorption in colon likely when absorption is limited in small intestine
Zinc	Absorption in colon hypothesized during deficiency

*It is unclear how colonic absorption influences nutrient status

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Schafer AL. *J Steroid Biochem Mol Biol.* 2017;173:202. doi:10.1016/J.JSBMB.2016.12.012

Nutrient Interactions



Calcium & Iron

- Calcium between 300-600mg has shown to inhibit heme and nonheme iron absorption after dietary and supplemental intake.
- Why? Here are a few hypotheses:
    - Calcium may decrease DMT1 expression and move away from apical membrane
    - Calcium causes ferroportin to relocate from basolateral membrane to cytosol
    - Change in membrane fluidity

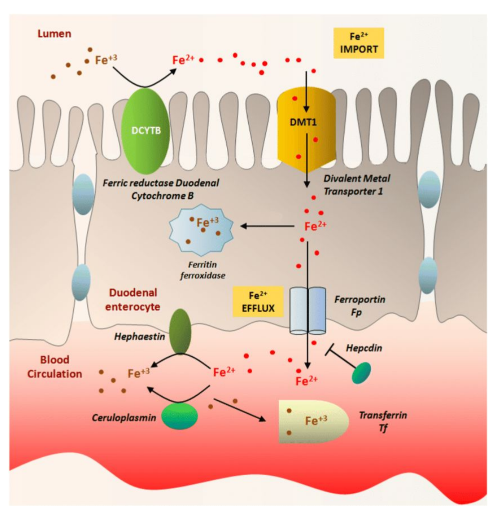


Image from Bjørklund et al 2020;94(3). doi: 10.1007/s00204-020-02652-2.

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Shawki & Mackenzie. *Biochem Biophys Res Commun.* 2010;393(3). doi: 10.1016/j.bbrc.2010.02.025.

Calcium & Iron

- Relationship between Ca intake/supplementation on iron absorption, ferritin status, & hemoglobin levels.
    - Calcium intake was inversely related to iron absorption, but not ferritin or hemoglobin concentration.
    - Dose-response relationship was statistically significant for lower ferritin concentrations.

The Journal of Nutrition
Nutrient Physiology, Metabolism, and Nutrient-Nutrient Interactions

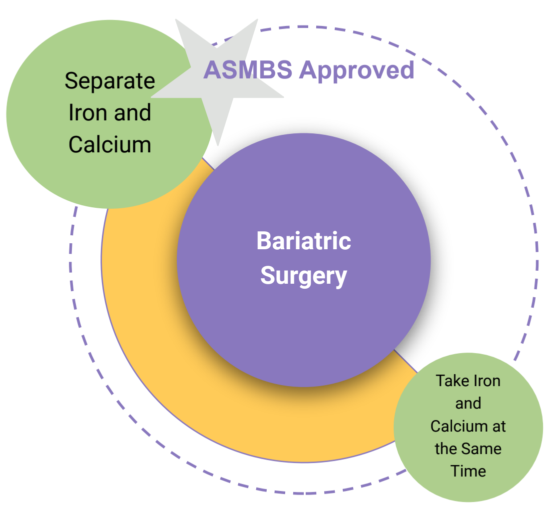
Calcium Intake and Iron Status in Human Studies: A Systematic Review and Dose-Response Meta-Analysis of Randomized Trials and Crossover Studies

Ajibola Ibraheem Abioye,[1] Taofik A Okuneye,[2] Abdul-Majeed O Odesanya,[3] Olufunmilola Adisa,[4] Asanat I Abioye,[5] Ayorinde I Soipe,[6] Kamal A Ismail,[7] JaeWon F Yang,[8] Luther-King Fasehun,[9] and Moshood O Omotayo[10,11]

- Limitations and things to consider:
    - *Free-living population, including children.
    - Various calcium forms used, no indication of if taken with/without meals.

Abioye et al. *J Nutr.* 2021;151(5). doi: 10.1093/jn/nxaa437.

Calcium & Iron



Vitamin C & Iron

- Vitamin C supports ferric → ferrous iron conversion
    - Needed for duodenal cytochrome b (DCYTB) and other ferrireductase
    - Increase Fe(2+) available to transport via DMT1
- Vitamin C complexes with ferric iron for membrane transport.
    - Fe(3+)-ascorbate complex

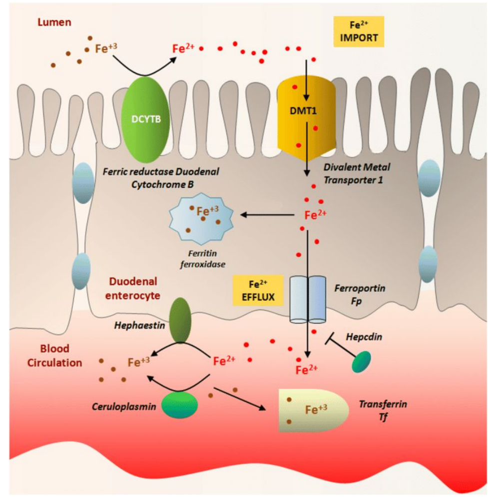


Image from Bjørklund et al 2020;94(3). doi: 10.1007/s00204-020-02652-2.

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Kontoghiorghes et al. *Medicines (Basel).* 2020;7(8):45. doi: 10.3390/medicines7080045

Vitamin C & Iron

- After Bariatric Surgery
    - ASMBS recommended combination
    - Combination of Vitamin C and iron supplementation saw significant improvements in labs

Obesity Surgery, **9**, 17–21

Iron Absorption and Therapy after Gastric Bypass

Barbara M. Rhode, PDt, MSc (Nutr); Chaim Shustik, MD, FRCP(C); Nicolas V. Christou, MD, PhD, FACS; Lloyd D. MacLean, MD, FRCS(C), FACS

Department of Surgery and Division of Hematology, Royal Victoria Hospital, McGill University, Montreal, Quebec, Canada

Iron Therapy after Gastric Bypass

Table 1. Response of hemoglobin and serum ferritin concentrations to ingestion of oral iron with and without vitamin C

Parameters	Pre	Iron	Iron + vitamin C
Hemoglobin (g/L)	116 ± 16*	123 ± 14†	128 ± 14‡
Serum ferritin (μg/L)	9.7 ± 6.2¶	14.8 ± 9.9‖	21.8 ± 13.7**
Anemia (%)	62	41	28

*$P < 0.01$, pre versus iron.
†$P < 0.05$, iron versus iron + vitamin C.
‡$P < 0.001$, pre versus iron + vitamin C.
¶$P < 0.05$, pre versus iron.
‖$P < 0.01$, iron versus iron + vitamin C.
**$P < 0.001$, pre versus iron + vitamin C.

Rhode et al. *Obes Surg.* 1999;9(1). doi: 10.1381/096089299765553656.

Calcium & Vitamin D

- Vitamin D promotes calcium absorption and homeostasis
  - Absorption via active transport (duodenum, jejunum)
    - Induces calbindin and other calcium transcellular transporters
  - Absorption via passive diffusion (jejunum, ileum)
    - Vitamin D enhances gene expression of transmembrane proteins like Claudin-2

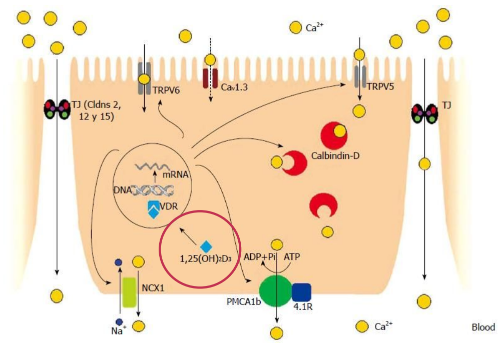


Image from Diaz de Barboza et al.. Molecular aspects of intestinal calcium absorption. *World J Gastroenterol.* 2015;21(23). doi: 10.3748/wjg.v21.i23.7142.

Celebrate

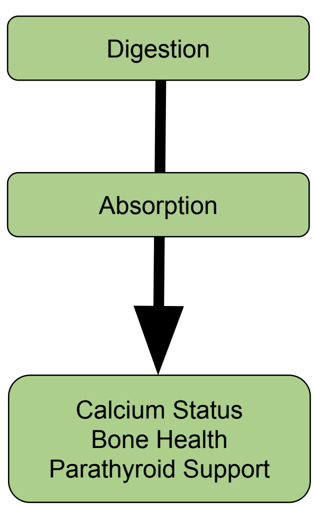
Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Fujita et al. *Mol Biol Cell.* 2008;19(5):1912-21. doi: 10.1091/mbc.e07-09-0973.

Optimizing Calcium Absorption

Enhancers

- Fructose
- Lactose
- Sugar Alcohols

- Vitamin D
- Protein



Inhibitors

- Phytic Acid
- Oxalic Acid
- Unabsorbed Fatty Acids

- Magnesium
- Zinc

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.

Zinc & Copper

- High intakes of zinc inhibits copper absorption
    - Excess zinc upregulates metallothionein, which acts as a buffer with copper and reduces its functional use
    - Associated with copper deficiency
- Prophylactic copper supplementation is effective
    - ASMBS recommends 8-15mg zinc for every 1 mg copper

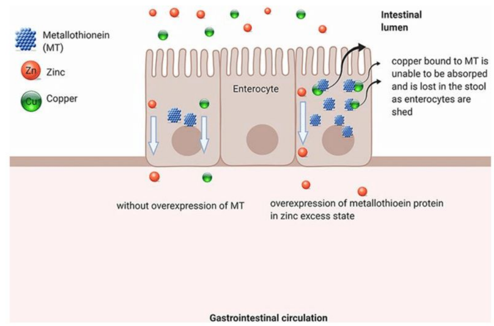


Image retrieved from Munie et al. (2021), *Case Rep Nephrol Dial., 11*(2). DOI: 10.1159/000512612.

Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Gletsu-Miller & Wright. (2013). *Adv. Nutr, 4.* doi:10.3945/an.113.004341
Tapiero et al. *Biomed Pharmacother. 57*(9), DOI: 10.1016/s0753-3322(03)00012-x.
Mechanick et al. (2019) *Endocr Pract., 25*(12). doi:10.4158/GL-2019-0406

Animal Proteins & Amino Acids

- Enhancers
    - Protein is thought to promote calcium & magnesium absorption/retention
    - Red meat, poultry, fish contain digestive products that may aid in iron absorption
    - Dairy proteins (casein, whey) may help increase passive diffusion of calcium
    - Sulfur-containing amino acids (Methionine, Cysteine) may promote bioavailability of minerals like zinc and selenium
- Inhibitor
    - Sulfur-containing amino acids may increase urinary excretion of calcium*
    - Raw fish contain thiaminases

Higdon & Drake. *An Evidence-Based Approach to Vitamins and Minerals.* 2nd ed. 2012.
Gropper et al. *Advanced Nutrition and Human Metabolism.* 7th Edition. 2008.
Schuchardt & Hahn (2017). *Curr Nutr Food Sci. 13*(4). DOI: 10.2174/1573401313666170427162740
Melse-Boonstra, A. (2020). *Font Nutr, 7*(101). DOI: 10.3389/fnut.2020.00101.

Phytic Acid

- Phytic acid chelates with various minerals including iron, calcium, magnesium, copper, zinc and selenium.

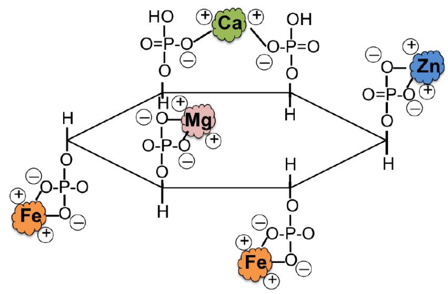


Figure 3. Phytic acid as chelator of divalent cations of iron (Fe^{2+}), zinc (Zn^{2+}), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

Image retrieved from Majumder et al. 2019. Agronomy, 9, 803. 10.3390/agronomy9120803

Bronus, F. (2022). *Nutrients 14*(1), 25. DOI: 10.3390/nu14010025
Gropper et al. *Advanced Nutrition and Human Metabolism. 7th Ed. 2018*

Oxalic Acid

- Calcium and oxalic acid create CaOx salts in the intestine
  - Increases calcium excretion from fat malabsorption
  - Free oxalates bind with unabsorbed calcium and can contribute to kidney stone formation.
- Oxalic acid also inhibits zinc, nonheme iron, & magnesium.

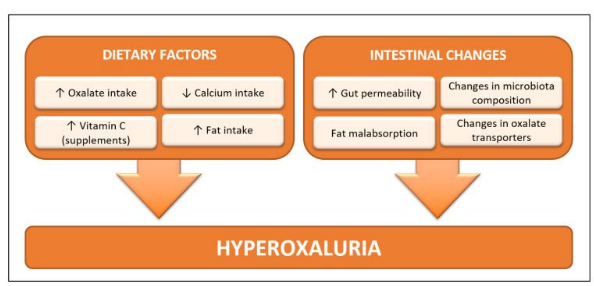


Image retrieved from Ormanji et al., *Nutrients*, 2020, 12(5); 1442. 10.3390/nu12051442

Ormanji et al., *Nutrients*, 2020, 12(5); 1442. 10.3390/nu12051442
Gropper et al. *Advanced Nutrition and Human Metabolism. 7th Ed. 2018*

Phytic Acid, & Oxalic Acid

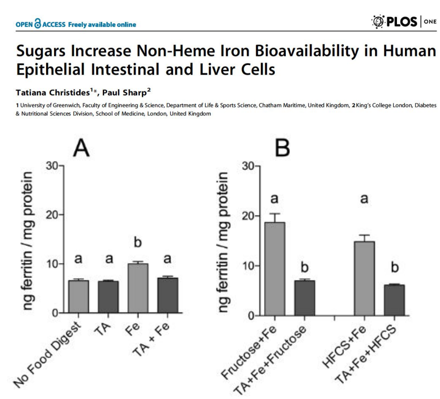
- In most cases, no need to reduce whole grain and other foods high in fiber, phytates, or oxalates.
- Special attention to vegetarian/vegan patients, supplement schedules, excess of one food.
- Investigate extra Vitamin C supplementation

- **Decreasing Phytic Acid Content**
  - Food manufacturing and processing
  - Cooking with heat
  - Soaking beans
- **Decrease High Oxalic Acid Foods**
  - Teas
  - Rhubarb
  - Spinach
  - Beets
  - Turnips
  - Potatoes

Brouns F. *Nutrients.* 2021;14(1):25. doi: 10.3390/nu14010025.
Ormanji et al. *Nutrients.* 2020;12(5):1442. doi: 10.3390/nu12051442.
NIH ODS. Calcium - Health Professional Fact Sheet. 2021.

Sugars & Sugar Alcohols

- Fructose
  - Reduce nonheme ferric iron → ferrous iron or form chelates
  - Not likely to overcome inhibition of phytic acid or tannins in fruits
  - Thought to increase magnesium absorption
- Lactose
  - Thought to increase solubility of calcium
- Sugar Alcohols
  - Thought to increase iron absorption
  - Thought to improve calcium solubility


OPEN ACCESS Freely available online — PLOS ONE

Sugars Increase Non-Heme Iron Bioavailability in Human Epithelial Intestinal and Liver Cells

Tatiana Christides[1]*, Paul Sharp[2]

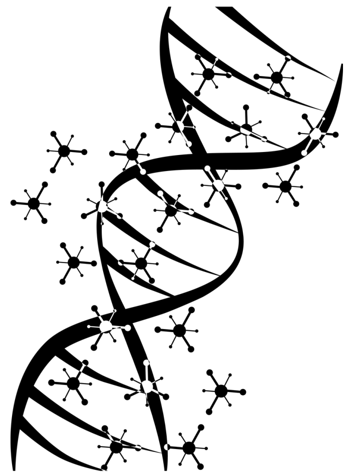
1 University of Greenwich, Faculty of Engineering & Science, Department of Life & Sports Science, Chatham Maritime, United Kingdom, 2 King's College London, Diabetes & Nutritional Sciences Division, School of Medicine, London, United Kingdom

Figure 3. Effect of tannic acid (TA) and fructose, or TA and high-fructose corn syrup (HFCS), on iron-induced ferritin formation. Measurement of Caco-2 cell ferritin formation from digests

Christides & Sharp. *PlosONE 2013;8*(12). DOI: 10.1371/jounral.pone.0083031
Gropper et al. *Advanced Nutrition and Human Metabolism. 7th Ed. 2018*

Nutrigenetics, Nutrigenomics & Nutrient Absorption

- Certain single nucleotide polymorphisms (SNPs) inform effectiveness of enzymes to support micronutrient absorption and utilization.
- Utilize knowledge to optimize dietary and supplement interventions



Genes to Consider -

- Vitamin D 25-Hydroxylase Enzyme is needed for the conversion of inactive 25(OH)D → 1,25(OH)D in liver
  - Instructions provided by CYP2R1 Gene
- Vitamin D Receptor (VDR) transcription factor that regulates binding of active vitamin D.
  - Instructions provided by VDR Gene

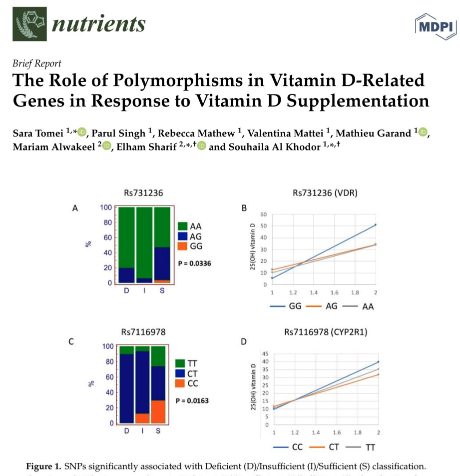
Table 3. Association of genotypes with R/NR and S/D/I (chi-square). Significant *p*-values are in bold.

SNP ID	Gene	*p*-Value (R/NR)	*p*-Value (S/D/I)
rs10783219	VDR	0.6071	0.5330
rs7139166	VDR	0.4249	0.6209
rs731236	VDR	0.5133	**0.0336**
rs757343	VDR	0.6023	0.6926
rs10741657	CYP2R1	0.3748	0.4870
rs10766197	CYP2R1	0.7235	0.3820
rs12794714	CYP2R1	0.7221	0.8857
rs1562902	CYP2R1	0.3136	0.1389
rs10500804	CYP2R1	0.7443	0.8867
rs1993116	CYP2R1	0.6900	0.6161
rs7116978	CYP2R1	0.0727	**0.0163**
rs10877012	CYP27B1	0.7108	0.3583
rs4646536	CYP27B1	0.8004	0.8265
rs703842	CYP27B1	0.7845	0.7230
rs12785878	DHCR7/NADSYN1	0.9386	0.9820
rs3829251	DHCR7/NADSYN1	0.7488	0.4279
rs1155563	GC	0.9104	0.9904
rs12512631	GC	0.3288	0.1126
rs17467825	GC	0.0661	0.1188
rs222020	GC	0.4039	0.4397
rs2282679	GC	0.9068	0.7540
rs2882679	GC	0.4395	0.6346
rs3755967	GC	0.8826	0.5654
rs4588	GC	0.2287	0.1922
rs7041	GC	0.1961	0.2328
rs17219315	CYP24A1	0.6713	0.3635
rs2244719	CYP24A1	0.7235	0.3820
rs229624	CYP24A1	0.8586	0.8796
rs2296241	CYP24A1	0.3863	0.4631
rs2426496	CYP24A1	0.4395	0.6346
rs4809960	CYP24A1	0.5668	0.1768
rs6013897	CYP24A1	0.7249	0.9156

etics.com/
u12092608

Nutrigenetics - Vitamin D

- Look at associations between genotype and response to vitamin D supplementation.
- Who may respond better to Vitamin D supplementation?
  - VDR Taq1 (rs731236) - GG Carriers
  - CYP2R1 (rs7116978) - CC Carriers
- How can we use this information to cater interventions?


nutrients

MDPI

Brief Report

The Role of Polymorphisms in Vitamin D-Related Genes in Response to Vitamin D Supplementation

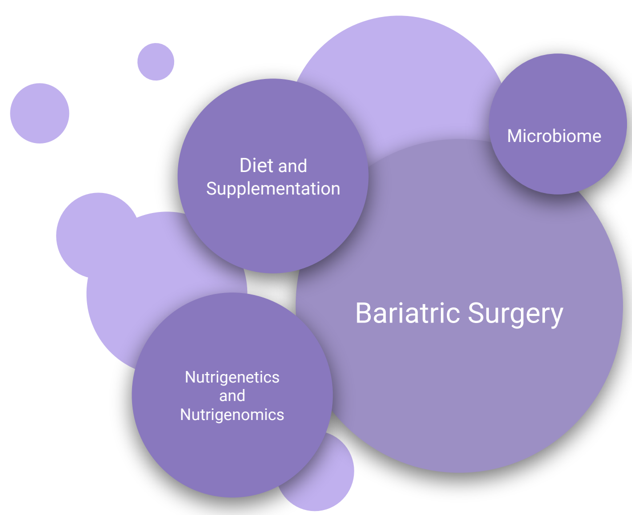
Sara Tomei [1,*], Parul Singh [1], Rebecca Mathew [1], Valentina Mattei [1], Mathieu Garand [1], Mariam Alwakeel [2], Elham Sharif [2,*,†] and Souhaila Al Khodor [1,*,†]

Figure 1. SNPs significantly associated with Deficient (D)/Insufficient (I)/Sufficient (S) classification.

Tomei et al. *Nutrients*, 2020: 12(9): 2608. DOI: 10.3390/nu12092608

What to do?

- Use labs and clinical assessment to determine priorities.
- Emphasize importance of adequate diet recalls/journals to determine pertinent nutrient-nutrient interactions.
- Reevaluate the supplement schedule (with food, what food, empty stomach, etc.)
- Consider nutrigenomic testing to evaluate nutrient absorption SNPs.



References

- Parrott J, Frank L, Rabena R, Craggs-Dino L, Isom KA, Greiman L. American Society for Metabolic and Bariatric Surgery Integrated Health Nutritional Guidelines for the Surgical Weight Loss Patient 2016 Update: Micronutrients. *Surgery for Obesity and Related Diseases.* 2017;13(5):727-741. doi:10.1016/j.soard.2016.12.018
- Kaidar-Person O, Person B, Szomstein S, Rosenthal RJ. Nutritional deficiencies in morbidly obese patients: A new form of malnutrition? Part A: Vitamins. *Obes Surg.* 2008;18(7):870-876. doi:10.1007/s11695-007-9349-y
- Kaidar-Person O, Person B, Szomstein S, Rosenthal RJ. Nutritional deficiencies in morbidly obese patients: A new form of malnutrition? Part B: Minerals. *Obes Surg.* 2008;18(8):1028-1034. doi:10.1007/s11695-007-9350-5
- Weight Management Dietetic Practice Group. *Pocket Guide to Bariatric Surgery.* Third Edition. (Isom KA, Majumdar MC, eds.).; 2022.
- Mechanick JI, Apovian C, Brethauer S, et al. Clinical Practice Guidelines For The Perioperative Nutrition, Metabolic, And Nonsurgical Support Of Patients Undergoing Bariatric Procedures - 2019 Update: Cosponsored By American Association Of Clinical Endocrinologists/American College Of Endocrinology, The Obesity Society, American Society For Metabolic & Bariatric Surgery, Obesity Medicine Association, And American Society Of Anesthesiologists - Executive Summary. Endocr Pract. 2019;25(12):1346-1359. doi:10.4158/GL-2019-0406
- Gropper S, Smith J, & Carr T., eds. *Advanced Nutrition and Human Metabolism.* 7th Ed. Boston, MA: Cengage Learning; 2018.
- Tapiero, H, Townsend, DM, Tew, KD. Trace elements in human physiology and pathology. Copper. *Biomed Pharmacother.* 2003; 57(9): 386-398. DOI: 10.1016/s0753-3322(03)00012-x
- Bjørklund G, Peana M, Pivina L, Dosa A, Aaseth J, et al. Iron Deficiency in Obesity and after Bariatric Surgery. *Biomolecules.* 2021; 11(5), 613. DOI: 10.3390/ biom11050613
- Image: Cornelissen A, Guo L, Sakamoto A, Virmani R, & Finn AV. New insights into the role of iron in inflammation and atherosclerosis. *eBioMedicine.* 2019; 47, 598-606. DOI: 10.1016/j.ebiom.2019.08.014
- Said HM. Intestinal absorption of water-soluble vitamins in health and disease. *Biochemical Journal.* 2011;437(3):357-372. doi:10.1042/BJ20110326
- National Institute of Health. Riboflavin - Health Professional Fact Sheet. Web site. https://ods.od.nih.gov/factsheets/Riboflavin-HealthProfessional/ Accessed March 24, 2022.
- National Institute of Health. Vitamin B12 - Health Professional Fact Sheet. Web site. https://ods.od.nih.gov/factsheets/VitaminB12-HealthProfessional/ Accessed March 23, 2022.
- Shawki A, Knight PB, Maliken BD, Niespodzany EJ, Mackenzie B. H(+)-coupled divalent metal-ion transporter-1: functional properties, physiological roles and therapeutics. *Curr Top Membr.* 2012;70:169-214. doi: 10.1016/B978-0-12-394316-3.00005-3.

References

- Image: Bjørklund G, Dadar M, Peana M, Rahaman MS, Aaseth J. Interactions between iron and manganese in neurotoxicity. Arch Toxicol. 2020 Mar;94(3):725-734. doi: 10.1007/s00204-020-02652-2. Epub 2020 Mar 16. PMID: 32180038.
- Lefebvre T, Coupaye M, Esposito-Farèse M, Gault N, Talbi N, et al. Hepcidin and Iron Deficiency in Women One Year after Sleeve Gastrectomy: A Prospective Cohort Study. *Nutrients.* 2021;13(8):2516. doi: 10.3390/nu13082516.
- Seeley RJ, Chambers AP, Sandoval DA. The role of gut adaptation in the potent effects of multiple bariatric surgeries on obesity and diabetes. *Cell Metab.* 2015;21(3):369-78. doi: 10.1016/j.cmet.2015.01.001.
- Camastra S, Palumbo M, Santini F. Nutrients handling after bariatric surgery, the role of gastrointestinal adaptation. *Eat Weight Disord.* 2022;27(2):449-461. doi: 10.1007/s40519-021-01194-5.
- Schafer AL. Vitamin D and Intestinal Calcium Transport After Bariatric Surgery. *J Steroid Biochem Mol Biol.* 2017;173:202. doi:10.1016/J.JSBMB.2016.12.012
- Abioye AI, Okuneye TA, Odesanya AO, Adisa O, Abioye AI, et al. Calcium Intake and Iron Status in Human Studies: A Systematic Review and Dose-Response Meta-Analysis of Randomized Trials and Crossover Studies. J Nutr. 2021 May 11;151(5):1084-1101. doi: 10.1093/jn/nxaa437.
- Kontoghiorghes GJ, Kolnagou A, Kontoghiorghe CN, Mourouzidis L, Timoshnikov VA, Polyakov NE. Trying to Solve the Puzzle of the Interaction of Ascorbic Acid and Iron: Redox, Chelation and Therapeutic Implications. *Medicines (Basel).* 2020;7(8):45. doi: 10.3390/medicines7080045.
- Rhode BM, Shustik C, Christou NV, MacLean LD. Iron absorption and therapy after gastric bypass. *Obes Surg.* 1999;9(1):17-21. doi: 10.1381/096089299765553656.
- Fujita H, Sugimoto K, Inatomi S, Maeda T, Osanai M, et al.. Tight junction proteins claudin-2 and -12 are critical for vitamin D-dependent Ca2+ absorption between enterocytes. *Mol Biol Cell.* 2008;19(5):1912-21. doi: 10.1091/mbc.e07-09-0973.
- Image: Diaz de Barboza G, Guizzardi S, Tolosa de Talamoni N. Molecular aspects of intestinal calcium absorption. World J Gastroenterol. 2015 Jun 21;21(23):7142-54. doi: 10.3748/wjg.v21.i23.7142.
- Ko BJ, Myung SK, Cho KH, Park YG, Kim SG, et al. Relationship Between Bariatric Surgery and Bone Mineral Density: a Meta-analysis. *Obes Surg.* 2016;26(7):1414-21. doi: 10.1007/s11695-015-1928-8.
- Christides T & Sharp P. Sugars increase non-heme iron bioavailability in human epithelial intestinal and liver cells. *PLoSOne. 2013; 8*(12), e83031. DOI: 10.1371/journal.pone.0083031.
- 3X4 Genetics. (2023) Clinical Guide. https://3x4genetics.com/
- Tomei, S., Singh, P., Matthew, R., Mattei, V., Garand, M. et al. (2020). The role of polymorphisms in vitamin D-related genes in response to Vitamin D supplementation. *Nutrients. 12*(9), 1-16. DOI: 10.3390/nu12092608

Thank You!

Taylor Brodie, MS, RDN, LD

Clinical Nutrition Liaison

Celebrate Vitamins

taylor@celebratevitamins.com

linkedin.com/in/taylor-brodie