

# Micronutrient intakes and plasma antioxidant micronutrients on low-carbohydrate diets – a systematic review

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Low-carbohydrate diets (LCD) are increasingly used and promoted for weight management<sup>(1)</sup>. Limiting carbohydrate-rich foods such as wholegrains and cereals may reduce consumption of B-vitamins and minerals, even causing beri-beri with extreme carbohydrate (CHO) avoidance<sup>(2)</sup>.

Studies of LCDs reporting micronutrient intake and status were systematically reviewed. Web of Science, Medline (OVID), EMBASE (OVID), Scopus, Cochrane Library and ClinicalTrials.gov were searched from inception to September 2017. Two reviewers independently performed study selection and data extraction. After duplicate removal, 475 titles and abstracts were considered, and 47 were selected for full-text screening. Five studies met the inclusion criteria (studies of LCDs; reporting on micronutrient intake and status) for the review.

The cross-sectional study of Icelandic adults voluntarily following LCD (average 8%E from CHO) reported consumptions below recommended daily intakes for thiamin, folate, vitamin C, calcium, magnesium and iron in 50% of women, thiamin and folate in 25% of men, and iron and magnesium in 75% of men<sup>(3)</sup>. RCTs (n = 4) findings are tabulated.

RCT	Diet & Subjects	Changes from baseline within LCD arm	Compared to control diet
Truby 2008 UK	Atkins, Weight Watcher, Slimfast, Rosemary Conley. 2 months, n = 293 OW/OB.	All micronutrients fell from baseline values. Only <b>selenium</b> rose from 100% to 149%RNI. Following nutrients were below RNI at 2 months: <b>Folate</b> 93%RNI; <b>Ca</b> 92%RNI; <b>Mg</b> 75%RNI; <b>Potassium</b> 67%RNI; <b>Iron</b> 91%RNI.	No statistical comparison of intakes between diet groups.
Gardner 2010 USA	Atkins (17% CHO) Zone, LEARN, Ornish. 8 weeks, n = 291 OW/OB.	Proportion of subjects with intake above EAR at baseline but then below EAR after 8 weeks of Atkins diet are as follows: 53% for <b>thiamin</b> , 48% for <b>folate</b> , 29% for <b>vitamin C</b> , 30% for <b>iron</b> and 33% for <b>magnesium</b> .	At 8 weeks: Atkins vs. LEARN <sup>b</sup> , mean (sd.) <b>Thiamin</b> 0.9 (0.4) vs. 1.4 (0.4) mg/d. <b>Folate</b> 329 (141) vs. 470 (190) µg/d. <b>Vitamin C</b> 66 (39) vs. 100 (62) mg/d. <b>Iron</b> 10.5 (4.1) vs. 13.7 (5.2) mg/d. <b>Mg</b> 231 (86) vs. 286 (89) mg/d. <b>Selenium</b> , 114 (44) vs. 97 (34) µg/d. <b>Zn</b> , 11.0 (3.5) vs. 8.9 (3.1) mg/d. Mean difference of change (95%CI). <b>Thiamin</b> -0.63 (-1.2, -0.01) mg/d. <b>Iodine</b> -47.86 (-79.2, -16.5) µg/d. <b>Na</b> -1055.09 (-1592.6, -517.6) mg/d. <b>Ca</b> -292.38 (-485.8, -99.0) mg/d. <b>Vitamin C</b> 68.82 (15.2, 122.5) mg/d. <b>Vitamin E</b> 6.49 (1.8, 11.2) mg/d. <b>β-Carotene</b> 6776.93 (2143.7, 11410.2) µg/d. <b>Vitamin A equivalents</b> 1001.36 (207.7, 1795.0) µg/d.
Genoni 2016 Australia	Paleolithic diet <sup>a</sup> (28% CHO) vs. Australian guideline. 4 weeks, n = 39 healthy women.	Change from baseline: mean (sd.) <b>Thiamin</b> 1.55 (0.6) to 0.96 (0.5) mg/d. <b>Folate</b> 396 (136) to 317 (85) µg/d. <b>Iodine</b> 120 (39) to 64 (23) µg/d. <b>Ca</b> 771 (204) to 355 (91) mg/d. <b>Iron</b> 12.7 (2.6) to 11.1 (2.7) mg/d. <b>Vitamin C</b> 107 (50) to 168 (84) mg/d. <b>Vitamin E</b> 9.8 (2.5) to 14.3 (7.3) mg/d. <b>Vitamin A equivalents</b> 1015 (448) to 2032 (1359) µg/d. <b>RBC folate</b> 894 (214) to 981 (300) nmol/l.	LCD vs. MCD: Plasma <b>Retinol</b> 0.456 vs. 0.525 µg/ml. <b>Lycopene</b> 0.244 vs 0.483 µg/ml. <b>α-Carotene</b> 0.035 vs. 0.045 µg/ml. <b>β-Carotene</b> 0.132 vs 0.157 µg/ml. <b>Xanthophyll</b> 0.198 vs 0.159 µg/ml. <b>Vitamin C</b> 51.7 vs. 44.18 µmol/l.
Johnstone 2011 UK	Atkins style: LCD (4% CHO) vs. MCD (37% CHO), 4 weeks, cross-over, n = 16, OW/OB.	Plasma: <b>Retinol</b> 0.623 to 0.456 µg/ml. <b>α-Tocopherol</b> 11.46 to 9.30 µg/ml. <b>β-Cryptoxanthin</b> 0.065 to 0.039 µg/ml. <b>Lycopene</b> 0.392 to 0.244 µg/ml. <b>α-Carotene</b> 0.039 to 0.035 µg/ml. <b>β-Carotene</b> 0.135 to 0.132 µg/ml. <b>Xanthophyll</b> 0.186 to 0.207 µg/ml. <b>Vitamin C</b> 46.5 to 51.7 µmol/l.	

LEARN: Lifestyle, Exercise, Attitudes, Relationships, Nutrition; OW/OB: overweight and obesity; MCD: medium carbohydrate diet  
<sup>a</sup>Paleolithic diet: omit grains, cereals, legumes, white potato, corn and dairy products.

A limited number of studies reported on micronutrient status and intakes, with varying definition of what constitutes a LCD (varying CHO intakes, always below 45%E). Reduced intakes of thiamin, magnesium, calcium, iron and iodine are noteworthy, compared to within-group baseline or control diets – however, adverse effect related to micronutrient deficiencies were not reported for any of the studies. Longer-term studies focusing on biological markers of micronutrient status with a standardised definition of LCD are needed.

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