Paradoxical nutritional deficiency in overweight and obesity: the importance of nutrient density

Tania P Markovic and Sharon J Natoli

ABSTRACT

- Overweight and obese patients may develop paradoxical nutritional deficiency from eating high-energy foods with a poor nutrient content. In such patients, this condition is probably under-recognised, and thus untreated.
- The nutrient density of foods has recently been defined by a score — the naturally nutrient-rich (NNR) score — which assesses the contribution a food makes to the nutrient intake of a 2000 calorie (8360 kJ) daily diet and includes 14 key macronutrients. NNR foods are whole foods that provide the highest nutrient-to-kilojoule ratio.
- An awareness of the importance of the nutrient density of foods can assist health practitioners to recognise and effectively manage paradoxical nutritional deficiency. Knowledge of the nutrient density of foods helps people wanting to reduce their kilojoule intake to maintain a nutritionally sound diet, providing adequate vitamins, minerals and macronutrients.

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In most regions of Australia, food is available in excessive quantities. How then is it possible that our patients experience nutritional deficiencies? As clinicians managing overweight and obese patients, we often find that they have previously overlooked and, at times, marked nutritional deficiencies.

Foods today are usually defined as "healthy" on the basis of a reduced content of "negative" nutrients, such as saturated fat, salt and sugar, but this provides an incomplete assessment. There is now increasing recognition of the importance of nutrient content relative to energy content of foods. This concept — the nutrient density of food — assists not only in identifying and treating nutritional deficiencies, but also in preventing them. Nutrient density is not a new term. Attempts to define nutritious food have been made since the early 1970s, and the term nutrient density has been used in the National Health and Medical Research Council's dietary guidelines for Australians since 1992.[1,2] However, what *is* new is the increased interest in arriving at a universal definition for this term.

In the typical case scenario presented in the Box (*page 150*), the patient had a dietary intake that was high in energy (kilojoules) but low in nutrients (vitamins and minerals), resulting in nutritional deficiency. The total caloric intake, as well as the breakdown of the macronutrients, vitamins and minerals in her diet before and after the intervention, shows that, despite an energy intake of 10 000 kJ before intervention, her diet was lacking in iron, folate, zinc, vitamin C and fibre.

Research in this area has grown since 2005 when United States dietary guidelines were updated from the simple food pyramid to advice about choosing "nutrient-dense foods", although no standard definition existed for such foods. In response, experts, like Adam Drewnowski from the University of Washington, have highlighted the issues surrounding the use of the term by developing and introducing a scoring system — the naturally nutrient-rich (NNR) score — for ranking a food's nutrient density.[5] The NNR score assesses the contribution a food makes to the nutrient intake of a 2000 calorie (8360 kJ) daily diet, and includes 14 key macronutrients. The 14 macronutrients are protein, calcium, iron, vitamin A, vitamin C, thiamin, riboflavin, vitamin B_{12}, folate, vitamin D, vitamin E, monounsaturated fat, potassium, and zinc. The nutrient contribution of each food is then compared with its kilojoule content. NNR foods are those providing the highest amounts of nutrients for the least amount of kilojoules.

An NNR diet requires the consumption of more dark-coloured fruits and vegetables, whole grains, lean meats, seafood, eggs, beans, nuts and low-fat dairy products.[5] Implementation of an NNR diet involves simple changes to everyday food choices within each of the major food groups. For example, the most nutritious fruits and vegetables include spinach, broccoli, tomato, rockmelon, mango, strawberries, kiwifruit, blueberries and avocado. Oysters, lean beef, turkey, eggs, low-fat milk and yoghurt stand out in the meat and dairy groups, while wholegrain bread and oats are ranked highly in the breads and cereals group.

Our patient was able to reduce her weight and improve her nutrition on a diet with a *higher* nutrient density. As well as her iron and folate levels returning to normal, she derived other important benefits from weight loss: a lowering of blood pressure to the extent that she no longer required pharmacotherapy, a reduction in levels of blood glucose and γ-glutamyl transpeptidase, an improved lipid profile, and increased confidence and self-esteem.

A nutritionally sound diet is important for general wellbeing and the prevention of chronic diseases, such as heart disease, type 2 diabetes and certain cancers. Data from the World Cancer Research Fund and the American Institute for Cancer Research suggest that eating more fruit, vegetables, pulses and fibre, while reducing intakes of sugary drinks and energy-dense foods (particularly processed foods which are often high in sugar or fat and low in fibre), protects against a range of cancers including cancers of the mouth, pharynx, larynx, oesophagus, lung, stomach and colon.[6] Higher intakes of fruit, vegetables, fish and fibre have also been shown to reduce the incidence of coronary heart disease and type 2 diabetes.[7-9]

The problem of nutritional deficiency is not restricted to those who are overweight or obese. Australian nutrition surveys show that inadequate intake of foods from the key food groups is widespread in the Australian community. For example, in the 1995 nutrition survey, over half the males aged 12–44 years and a third of the children aged 4–11 years had not eaten fruit the day before interview, and had suboptimal intakes of iron, zinc, magnesium and calcium.[10] Our intake of takeaway foods is increasing,[11] and these foods are often lacking in nutrients while having a high energy content.[12,13]

Population groups at particular risk of nutritional deficiencies include: children and teenagers, who are often fussy eaters and require a higher nutrient intake because of rapid growth; pregnant women, who require higher intakes of vitamins and minerals; and

Recognising and managing paradoxical nutritional deficiency — a typical case scenario*

A 30-year-old woman was referred to a specialist clinic for weight management. She had a history of obesity dating from early childhood and was receiving a Disability Support Pension. She reported doing minimal physical activity, spending most of her time watching television and DVDs. She presented as very shy and self-conscious.

She reported that she skipped breakfast, usually had ham and cheese spread sandwiches for lunch, and an evening meal of takeaway barbecue chicken or fried fish, or pre-prepared rissoles, with potato or hot chips. She often had ice-cream for dessert. She drank soft drinks or cordial.

Her weight was 172.3 kg, height 1.68 m, body mass index (BMI) 60.5 kg/m^2, and waist circumference 142 cm. She had hypertension (blood pressure, 130/90 mmHg), osteoarthritis of the knees, and moderate sleep apnoea. Her menses were regular. She was taking ramipril 10 mg daily for hypertension, and paracetamol as needed for the arthritic pain. She did not have goitre, and there were no signs of androgen or cortisol excess. No abnormality was detected on cardiorespiratory, abdominal or neurological examination.

Investigations revealed normochromic, normocytic anaemia (haemoglobin level, 100 g/L; reference range [RR], 120–150 g/L). Her vitamin B_{12} and folate levels were normal, but the red-cell folate level was low (231 nmol/L [RR, ⩾ 310 nmol/L]), and iron studies showed iron deficiency (iron level, 8 μmol/L [RR, 9.0–31.0 μmol/L]; transferrin saturation, 12% [RR, 16%–60%]; and ferritin level, 13 μg/L [RR, 15–200 μg/L]). Electrolyte and creatinine levels were normal. Liver function tests gave normal results, apart from mild elevation of the γ-glutamyl transpeptidase level at 55 U/L (RR, ⩽ 35 U/L). Her fasting glucose level was mildly elevated at 5.6 mmol/L (RR, 3.0–5.4 mmol/L), but results of an oral glucose tolerance test were normal. Her lipid levels were mildly abnormal: total cholesterol, 5.9 mmol/L (RR, 3.9–5.5 mmol/L); triglycerides, 1.8 mmol/L (RR, 0.5–1.7 mmol/L); high-density lipoprotein [HDL] cholesterol, 1.3 mmol/L (RR, 0.9–2.1 mmol/L); and low-density lipoprotein [LDL] cholesterol, 3.9 mmol/L (RR, 1.7–3.5 mmol/L). Screening for coeliac disease with tissue transglutaminase antibody tests gave negative results.

The patient was provided with nutritional guidance and advised to increase her physical activity. She also received counselling and support to enhance behaviour modification. She began a regular gentle walk of 500 m twice daily. She was advised to stop consuming potato chips, cordial and soft drinks, and to limit her intake of takeaway food to, at most, one meal per week. Dietary intake changed as follows: for breakfast, multigrain toast with tomato and reduced-fat cheddar cheese; for morning tea, fruit; for lunch, a multigrain bread sandwich with margarine, ham, boiled egg or cheese, and one piece of fruit; for afternoon tea, low-fat yoghurt and rice crackers with peanut butter; for dinner, a serve of lean red meat, fish or skinless chicken (100 g) steamed, grilled, dry-fried or microwaved, with at least one cup of steamed, boiled or microwaved vegetables and one large potato, or half a cup of cooked rice or pasta; and, for supper, reduced-fat ice-cream. She was advised to drink only water or low-kilojoule cordial and soft drinks. The nutritional changes before and after the intervention are summarised in the Table.

Nutritional intake and percentage of recommended dietary intake (RDI), or other measure, before and after intervention

		Before intervention		After intervention	
Nutrient	RDI[3]	Intake	%RDI	Intake	%RDI
Energy (kJ)	8400*	10 000	119%	7000	83%
Protein (g)	46	88	192%	102	221%
Fat (g)	70†	103	147%	68	97%
Saturated fat (g)	24†	47	196%	23	98%
Carbohydrate (g)	310†	260	84%	166	53%
Sugar (g)	90†	127	141%	76	84%
Fibre (g)	25‡	10.8	43%	29.0	116%
Iron (mg)	18	6.7	37%	12.3	68%
Zinc (mg)	8	8.4	105%	13.3	166%
Calcium (mg)	1000	825	83%	1241	124%
Folate (μg)	400	139	35%	376	94%
Vitamin C	45	15	33%	147	326%
Vitamin A	700	605	86%	1381	197%
Sodium (mg)	460–920‡	4837	526% –1051%	1744	190%–379%

* RDI for energy based on age and height, using a physical activity factor of 1.4 (low activity). † As no RDI exists for these four nutrients, we used Food Standards Australia New Zealand recommended dietary intake values.[4] ‡ Adequate intake.

The absorption of folate varies between foods; however, bioavailability from foods is lower than from supplements. If a patient is clinically deficient in folate, a folic acid supplement should be used. As our patient was also iron deficient, she was prescribed a combined folic acid and iron supplement (87.4 mg of elemental iron and 300 μg of folic acid) daily for 3 months. Her folate deficiency was also treated by the addition of folate-rich foods (fruit and green vegetables).

The patient's weight declined by between 1 and 2 kg per month, consistent with adherence to the program of diet and gentle exercise. Her full blood count, iron studies, folate levels and liver function were normal within 6 months, by which time her weight was 163 kg, waist circumference 132 cm and her BMI had declined to 57.2 kg/m^2. Her blood pressure level improved and she was able to stop taking ramipril (blood pressure off-treatment, 120/70 mmHg). Her lipid and blood glucose levels also improved (total cholesterol, 5.0 mmol/L; triglycerides, 1.4 mmol/L; HDL, 1.3 mmol/L; LDL, 3.1 mmol/L; and fasting glucose, 5.1 mmol/L).

The patient's demeanour also changed in that she seemed more assertive and confident.

* The case described here is not an actual patient, but illustrates the typical features of patients with paradoxical nutritional deficiency. ◆

older people, who often have higher nutrient requirements but lower energy needs.

It is important to recognise that obesity may also be associated with nutrient deficiencies. One should not assume that a patient who is overweight has a nutritionally adequate diet. Similarly, when trying to lose weight by consuming less food, patients may unwittingly further reduce an already inadequate nutrient intake. However, if they choose nutrient-dense foods while limiting their intake of processed foods, they can still eat smaller amounts of food but ensure an adequate intake of macro- and micronutrients. Given the growing rates of obesity, it is important for people deciding to reduce their kilojoule intake to maintain a nutritionally sound diet, providing adequate vitamins, minerals and macronutrients.

Author details

Tania P Markovic, MB BS, FRACP, PhD, Endocrinologist[1]
Sharon J Natoli, BSc, BND, APD, Dietitian[2]

1 Department of Endocrinology, Royal Prince Alfred Hospital, Sydney, NSW.
2 Food & Nutrition Australia, Sydney, NSW.
Correspondence: tania_markovic@ozemail.com.au

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