

# Feeding the Foot: Nutrition and Diabetic Foot Ulcers

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**D**iabetic foot ulcers (DFUs) are a serious complication of diabetes that can impair quality of life and lead to further problems such as infection and possibly lower extremity amputations.

Globally, DFUs occur in 15% of those with diabetes and are seen more often in men and those with type 2 diabetes.<sup>1</sup> Other risk factors for DFUs include longer duration of diabetes, age, higher body-mass index (BMI) and tobacco use.

Individuals with diabetes are particularly vulnerable to foot ulceration due to the circulatory and neurological changes associated with the disease. These changes to blood vessels and peripheral nerves can result in loss of protective sensation and poor nutrient delivery to the extremities, leading to an increased risk of injury and poor healing.

Daily inspection of feet, annual foot exams, proper footwear and a healthy lifestyle are at the core of diabetes self-management education to prevent or identify early changes to the feet and efficiently treat ulcers if they occur. See Wounds Canada's comprehensive document [Caring for Your Feet: Safe Foot Care If You Have Diabetes](#), a patient-focused tool clinicians can use with patients.

Nutrition, however, is largely overlooked as part of the prevention and treatment of DFUs, despite the pivotal role it plays in the management of diabetes and prevention of diabetes-related complications.<sup>2-3</sup> Nutritional intake can impact

immune function, blood glucose levels, blood pressure, cholesterol, body weight and wound healing.<sup>4</sup> Wound healing alone is dependent upon adequate nutrition intake, and research shows that malnutrition may have a significant impact on limb-preservation outcomes for limb-threatening DFUs.<sup>5</sup> Nutrition support is a low-risk, cost-effective measure to prevent or treat DFUs and should be considered in all patients with diabetes.

To date, there are no evidence-based nutrition guidelines for the treatment and prevention of DFUs. It is unknown if the recently released evidence-based international guidelines for the prevention and treatment of pressure injuries can be extrapolated to DFUs.<sup>6</sup> In the absence of nutrition guidelines specifically for DFUs, however, these updated pressure injury guidelines should be considered when determining nutrition requirements for wound healing. (See [Nutrition and Pressure Injury Healing: Updated Recommendations](#) for a review of these guidelines.<sup>7</sup>)

But diabetic foot ulcers are a different wound from a pressure injury and may have different nutrition considerations. The question remains: Are there specific nutrient concerns for individuals with diabetes at risk for, or with, a DFU? There is increasing awareness that a person living with diabetes will face significant nutritional challenges that, if overcome, could ultimately prevent the development of a DFU or improve the chances that the ulcer will heal in a timely manner.<sup>8-9</sup> The remainder



of this article will focus on key nutritional areas to consider in the prevention and treatment of a DFU. Table 1 outlines the nutrition checklist for use in supporting a person with a DFU.

### Malnutrition Screening

Wound healing is an anabolic process that increases the nutritional needs for energy, protein, fluid and some micronutrients. Malnutrition

**Table 1:** Nutrition Checklist for DFU

✓	Malnutrition	Use a validated malnutrition screening tool.
✓	Glycemic Control	Target < 7% for most individuals with diabetes. <ul style="list-style-type: none"> <li>• Adjust or titrate diabetes medications.</li> <li>• Encourage low glycemic food choices.</li> <li>• Spread carbohydrates evenly through the day.</li> <li>• Encourage enhanced blood glucose monitoring.</li> </ul>
✓	Nutrition Recommendations	Provide adequate nutrition and hydration for wound healing while maintaining euglycemia. <ul style="list-style-type: none"> <li>• Energy: 30–35 kcal/kg/d</li> <li>• Protein: 1.25–1.5 g/kg</li> <li>• Fluid: 30 ml/kg (adjust for extra losses)</li> </ul>
✓	Key Micronutrients <ul style="list-style-type: none"> <li>• Vitamin D</li> <li>• B12 (especially with long-term metformin use)</li> <li>• Iron</li> <li>• Vitamin C</li> <li>• Zinc</li> </ul>	<ul style="list-style-type: none"> <li>• Correct deficiencies.</li> <li>• Offer general multivitamin/mineral supplement if intake is poor.</li> <li>• Supplement at physiological doses.</li> </ul>
✓	Patient-driven Care	<ul style="list-style-type: none"> <li>• Adapt diet for cultural and personal preferences.</li> <li>• Address chewing/swallowing safety.</li> <li>• Enhance eating environment.</li> <li>• Provide nutrition education to prevent malnutrition and enhance intake.</li> </ul>

can have a negative impact on wound healing. Some patients with diabetes may be at higher risk of malnutrition due to long-term restricted diets, poor access to adequate nutrition and drug–nutrient interaction. Some studies have shown a high rate of malnutrition in patients with diabetes.<sup>1,8,10</sup>

Not only have DFUs been shown to be associated with malnutrition, but nutrition status has been correlated with the severity of the ulcer, risk of infection and poor outcomes, such as amputation.<sup>1,5</sup> And as nutrition status worsens, the severity of DFUs (as measured by the Wagner ulcer classification system) and risk of infection increases. The wound itself may have a negative impact on nutrition status due to high nutrient demand for healing and loss of nutrients from wound exudate.<sup>11</sup>

For this reason, all patients with a DFU should be screened for malnutrition using a validated screening tool. The Mini Nutritional Assessment is a valid tool in treating diabetes.<sup>5</sup> Treating or preventing malnutrition repletes nutrition stores and ultimately improves wound healing. Nutritional assessment also addresses the underlying causes of malnutrition and supports a long-term nutrition care plan to prevent future episodes of malnutrition. For a further review of malnutrition and wound healing, see [Malnutrition in Wound Care](#).<sup>12</sup>

## Glycemic Control

Long-term elevated glucose can alter circulation and innervation that increases the risk of a DFU, along with other complications such as blindness, cardiovascular disease and renal impairment. Hyperglycemia contributes to blood vessel rigidity that impacts blood flow—resulting in poor oxygen and nutrient delivery to the wound bed.<sup>13</sup> In addition, hyper-

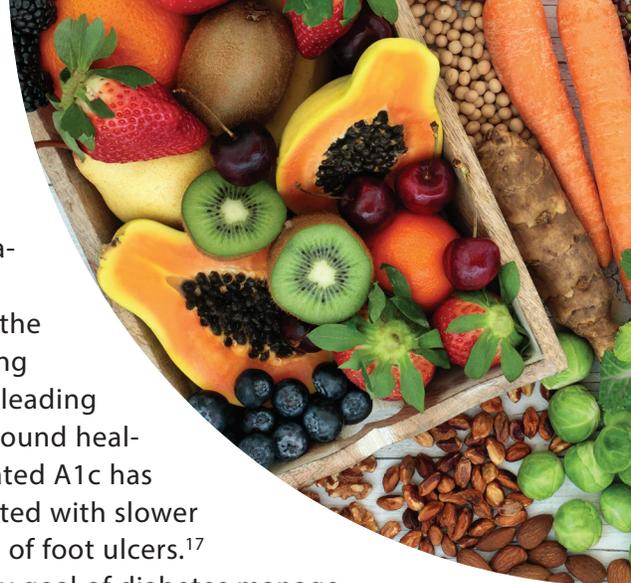
glycemia may impair the inflammatory process, interrupting the wound healing cascade and leading to delayed wound healing.<sup>14-16</sup> Elevated A1c has been associated with slower healing rates of foot ulcers.<sup>17</sup>

The primary goal of diabetes management is to maintain glucose levels at target, often measured by glycated hemoglobin (A1c). The A1c reflects the average blood glucose over a two- to three-month window.<sup>2</sup> While there is no specific A1c target to promote healing, the primary goal of preventing microvascular and neuropathic damage is supported by targeting an A1c below 7%.<sup>2</sup> For those at risk for hypoglycemia, targets may be set higher.

## Healthy Eating: Focus on Carbohydrates

A well-balanced diet that incorporates protein, carbohydrates and fat is the cornerstone of healthy eating for diabetes management. In diabetes, the focus is often on restricting or controlling carbohydrate intake. The challenge for patients is to support the elevated nutrition needs for wound healing and skin integrity while maintaining blood glucose levels at target. Insufficient carbohydrates during wound healing may result in protein being oxidized for energy and contribute to poor healing, muscle wasting and malnutrition. Carbohydrates contribute to energy needs, and the minimum recommended intake is no less than 130 grams per day for those over 18 years of age.<sup>18</sup> Food sources of carbohydrate (grains and starches, fruit, milk products) also provide valuable micronutrients that support wound healing.

Helping patients understand how food affects blood glucose is key to glycemic control. Basic nutrition education should include a review of the food sources of carbohydrates in the diet.





Diabetes Canada's *Beyond the Basics Meal Planning Guide* is one tool that teaches patients which foods have carbohydrates and how to practise portion control.

Patients should be encouraged to distribute carbohydrates throughout the day and include plenty of higher fibre foods and non-carbohydrate vegetables. Incorporating education on glycemic index shows patients how food impacts blood glucose. Oral hypoglycemic agents and/or insulin dose should be considered to assist patients in reaching their glycemic targets.

By reading food labels, patients can find out the available carbohydrate content of a food. (Available carbohydrate is the total carbohydrate content less the fibre content, in grams.) For those with the desire for more detailed nutrition education or those taking insulin or on pump therapy, learning carbohydrate counting and matching insulin (if taking) to food choices will assist in managing glucose levels.

Through blood glucose testing at home with a glucometer, flash or continuous glucose monitor, patients learn the effect of food and activity on glucose levels. Supporting patients in minimizing glucose excursions and recognizing and responding to their glucose patterns will prevent micro- and macrovascular changes.

## Protein: The Necessary Ingredient for Healing Wounds

Protein is vital throughout the wound healing cascade, as it is required for the synthesis of enzymes and the creation of collagen, connective tissue, capillaries and epithelial cells. Amino acids provide the building blocks of antibodies, macrophages and a healthy immune system. A lack of protein may prolong the inflammatory stage of wound healing, impair adequate collagen syntheses—leading to reduced tensile strength

of a closed wound—and increase the risk of a wound becoming chronic. Recommended intakes of protein that support wound healing are 1.25 to 1.5 g/kg.<sup>6</sup> Protein requirements need to be adjusted in patients with certain comorbidities, such as renal or liver disease.

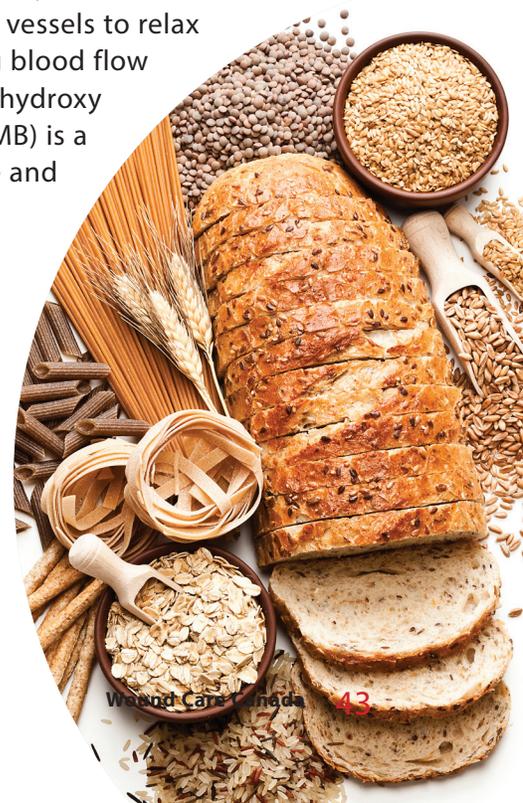
Protein-rich foods include meat, poultry, fish, eggs, milk products and legumes. Ensuring that protein is eaten at all meals fuels the requirements for tissue growth. Protein also slows stomach emptying and may lower the glycemic response when consumed with a carbohydrate-rich food.

## Arginine, Glutamine and Beta-hydroxy-beta-methylbutyrate (HMB)

Recent interest in specific amino acids and protein supplementation in diabetes is emerging.

Arginine and glutamine are two conditionally essential amino acids; our body naturally produces arginine and glutamine, but in times of stress, such as with a wound or sepsis, the body's demand for these amino acids outweighs supply, and they become conditionally essential and must be provided through the diet. These amino acids play an important role in repairing wounds, enhancing immune function, stimulating insulin secretion, promoting the transport of amino acids into tissue cells and supporting the synthesis of protein and collagen in the cells. Arginine is also a precursor to nitric oxide, a neurotransmitter that causes blood vessels to relax and dilate, improving blood flow to the wound bed. B-hydroxy B-methylbutyrate (HMB) is a metabolite of leucine and may enhance muscle protein synthesis.

For these reasons, there has been interest in using arginine, glutamine and HMB supplementation for patients with DFUs. Research suggests this type of supplement may



have value in the healing of DFUs, particularly in a subset of study subjects, including those with poor limb perfusion or low serum albumin levels.<sup>1,8</sup> Further research into this area is warranted. To date, however, these enhanced nutritional formulas are not available in Canada.

## Calories

Recommended energy intake for wound healing is estimated at 30 to 35 kcal/kg/day.<sup>6</sup> In patients with elevated BMI > 30, energy requirements may be tapered to 20 to 25 kcal/kg/day.



## Fat

Fat provides a source of calories that ensures sufficient energy intake with minimal effect on glycemia and provides essential fat-soluble vitamins. Monounsaturated fats and omega-3 polyunsaturated fats are often referred to as “healthy fats,” as they have positive effects on a patient’s lipid profile and cardiovascular outcomes.<sup>2</sup> Omega-3 fats may play an additional role in DFUs due to their anti-inflammatory and antioxidant effects.<sup>19</sup> Some research has shown enhanced ulcer healing with supplementation,<sup>20</sup> but further research is needed in this area.

Clinicians should encourage patients to choose olive and canola oil, and avocados, and to include nuts and seeds, in small portions, to ensure sufficient calorie and omega-3 intake. Omega-3 fats can be found in fatty fish (salmon, arctic char, mackerel, trout, herring and light tuna), seeds (flax, hemp) and nuts.

## Vitamins and Minerals

Several key micronutrients are involved in preserving skin integrity and wound healing. See Table 2 for a review of key nutrients and their function in wound healing. Note that general malnutrition screening may not be sensitive enough to detect micronutrient deficiencies.<sup>3</sup> While diabetes itself may not directly impact nutrition requirements, there is evidence of an association between DFUs and certain deficiencies.<sup>3,21–22</sup> Studies show that micronutrient deficiencies, including in vitamin C, zinc, iron and vitamin D, are common in those with DFUs.<sup>3,22–23</sup>

Clinicians should also consider drug–nutrient interactions. Metformin, often the first-line treatment for type 2 diabetes, will affect the absorption of B12 and has been associated with B12 deficiency. While not directly associated with wound healing, a B12 deficiency will have an impact on anemia, and it may present as peripheral neuropathy.<sup>24</sup>

Despite the association of micronutrient deficiencies and DFUs, there is limited evidence that supplementation will enhance ulcer healing or indications as to optimal intake levels to target.

This is largely due to the paucity of large RCTs and the variety of ways in which researchers have measured outcomes.<sup>4,11</sup>

### Adding Supplements?

At present there is insufficient evidence to support vitamin and mineral supplementation at levels *above* the daily recommended intake (DRI) for people with a DFU, unless a deficiency is suspected or confirmed. However, individuals with a DFU may not be able to consume an optimal diet and may have additional vitamin and mineral needs. These patients may benefit from a general daily multivitamin and mineral supplement to fill the nutrition gaps.<sup>4</sup> Supplementation without considering adequate energy, protein and hydration will do little to improve wound healing.

Clinicians should assess oral intake before considering additional micronutrient supplementation. Reviewing nutritional intake from all sources,

including current multivitamin/mineral supplements, oral nutrition supplements and fortified foods, ensures that over-supplementation or excessive intake does not occur. It is not uncommon for some patients to receive multiple sources of micronutrients with possible nutrient interactions (for example, long-term excess zinc intake may impact copper metabolism).<sup>13</sup>

### Conclusion

Healthy eating can impact glycemic control, wound healing and ultimately limb preservation. Those at risk for a DFU should receive foot care education on early warning signs and management of complications. In addition, all individuals at risk for a DFU should be screened for malnutrition and assessed by a registered dietitian with expertise in diabetes management. Patients may be at risk for some nutrition deficiencies, and nutrition therapy offers a low-risk, cost-effective

**Table 2:** Key Micronutrients and Their Functions in Wound Healing<sup>3,13,21,25</sup>

Micronutrient	Function in Wound Healing	DRI (Adults)
<b>Vitamin C</b>	<ul style="list-style-type: none"> <li>• Neutrophil migration</li> <li>• Fibroblast proliferation</li> <li>• Collagen formation</li> <li>• Immunity</li> <li>• Promotes iron absorption</li> </ul>	<ul style="list-style-type: none"> <li>• 75 mg/d women</li> <li>• 90 mg/d men</li> </ul>
<b>Vitamin A</b>	<ul style="list-style-type: none"> <li>• Stimulates immune system</li> <li>• Maintains mucosal and epithelial integrity</li> <li>• Collagen formation</li> </ul>	<ul style="list-style-type: none"> <li>• 700 mcg RAE women</li> <li>• 900 mcg RAE men</li> </ul>
<b>Vitamin D</b>	<ul style="list-style-type: none"> <li>• Possible role in glycemic control</li> <li>• Immune function</li> <li>• Reduces inflammation</li> </ul>	<ul style="list-style-type: none"> <li>• 600 IU</li> <li>• 800 IU &gt; 70 years</li> </ul>
<b>Copper</b>	<ul style="list-style-type: none"> <li>• Necessary for connective tissue and collagen synthesis</li> <li>• Red blood cell formation</li> </ul>	<ul style="list-style-type: none"> <li>• 900 µg/day</li> </ul>
<b>Iron</b>	<ul style="list-style-type: none"> <li>• Necessary for collagen synthesis and strength</li> <li>• T cell and phagocyte function</li> <li>• Needed for hemoglobin formation and oxygen transportation</li> </ul>	<ul style="list-style-type: none"> <li>• 8 mg/d</li> </ul>
<b>Zinc</b>	<ul style="list-style-type: none"> <li>• Synthesis of granulation tissue</li> <li>• Re-epithelialization</li> <li>• Anti-inflammatory and antimicrobial effects</li> <li>• Cell division, protein synthesis, collagen deposition</li> </ul>	<ul style="list-style-type: none"> <li>• 8 mg/d women</li> <li>• 11 mg/d men</li> </ul>

RAE: Retinol Activity Equivalents

DRI: Dietary Reference Intakes

way to support prevention and treatment of DFUs and to optimize wound healing.

By providing nutrition support, clinicians can also address the underlying cause of the deficiency or malnutrition and play a complementary role in helping patients prevent diabetes-related complications. Informed food choices, especially with regard to foods containing carbohydrates, can impact overall glycemic control while promoting adequate intake to support wound healing. 🍴

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