

# Returning to Physical Activity During Diabetes-Related Foot Ulcer Remission

Should we be dosing activity like we dose a drug?

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Approximately 40% of patients with diabetes-related foot ulcers (DFUs) will experience ulcer recurrence in the year after healing.<sup>1</sup> Hence, this period after ulceration is called “remission” due to this risk of re-ulceration typically due to the effect of sustained elevated foot pressure during weight-bearing activity in the presence of peripheral neuropathy.<sup>2</sup> In addition, most of these DFUs will develop on a different site compared to the index ulcer.<sup>3</sup>

The cost of treating people with DFUs is staggering; the mean cost of overall care can range from \$24,226 USD per wound episode to \$41,420 for inpatient admissions and \$11,265 for outpatient procedures.<sup>4</sup> A major contributor to this cost burden is hospital re-admission for complications in people with DFUs where 15% re-admission cost burden can be up to 210 million dollars in annual healthcare cost alone.<sup>5</sup> Therefore, attempts should be made to reduce recurrence if we are to successfully reduce this national and global footprint in burden.<sup>6,7</sup>

Thus, the concept of return to weight-bearing activity following an episode of DFU, while a person is in “DFU remission” is an important

yet undervalued concept in podiatric management given the need to manage a pressure-activity imbalance in a high-risk individual.<sup>8</sup> The shared-treatment goal between the interdisciplinary treating team, including the patient and caregivers, should be to reduce recurrence yet prolong ulcer-free, hospital-free, and

ple with DFUs.<sup>10</sup> The authors concluded that there was weak evidence for an inverse relationship between the amount of physical activity and plantar ulcer healing while utilizing off-loading devices.<sup>10</sup>

This lack of evidence on DFU healing is consistent with another review.<sup>11</sup> However, the prolonged use of

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activity-rich days for people in foot DFU remission.<sup>9</sup> Here, we report on some recent developments in the field with respect to dosing physical activity in foot ulcer remission and the advances in technology that are making this concept feasible and achievable.

## The Hiatus in Physical Activity During Foot Ulceration

A recent review of activity during foot ulceration reported on the results from several controlled trials and observational studies on step counts using activity monitors in peo-

knee-high, off-loading devices likely leads to a reduction in weight-bearing activity during active ulceration as the overall level of activity is much less (~ 3,000 to 4,000 daily steps less on average) when compared to people with peripheral neuropathy without foot ulcers.<sup>8</sup> The well-known American Diabetes Association (ADA) recommendation for daily physical activity in people with diabetes is 10,000 steps a day, but with the caveat that the presence of peripheral neuropathy, foot ulcers, and amputation should be accounted for first.<sup>12</sup>

*Continued on page 86*



## Physical Activity (from page 85)

This is consistent with the most recent recommendations from the International Working Group on the Diabetic Foot (IWGDF) advice on weight-bearing activity which is addressed later here.<sup>13</sup> Therefore, a daily step target that is safe and tolerable in people with active DFUs is likely to be much lower compared to their pre-ulcer baseline activity level and much less than their counterparts without a history of DFUs. However, the daily energy requirement to achieve this same level of activity is greater in people with active DFUs than in those without DFUs performing the same daily activities.<sup>14</sup>

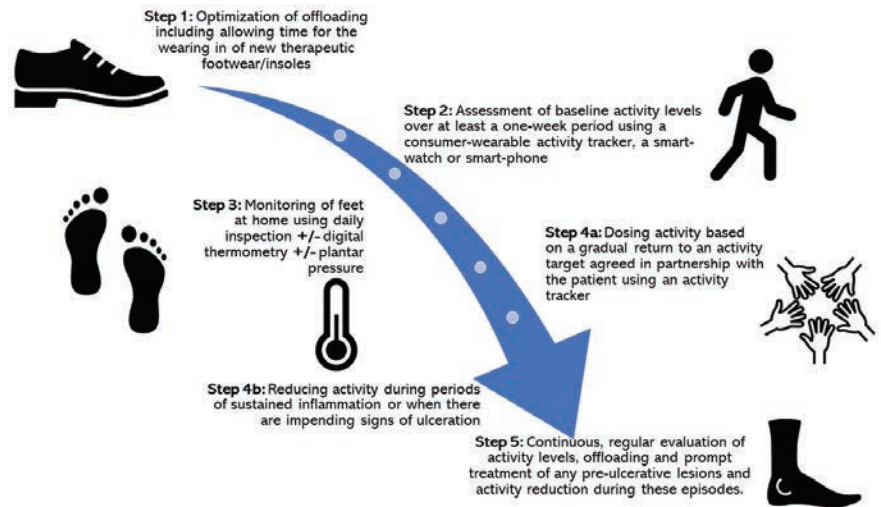


Figure 1: Proposed algorithm for return to activity

Legend: Five step guide on return to activity as proposed.<sup>8</sup>

## Rationale for Gradual Return to Physical Activity in Foot Ulcer Remission

Changes in weight-bearing activity following DFU healing may influence plantar tissue adaptation and increase the risk of ulcer recurrence.<sup>15</sup> Yet, there is a paucity of high-quality evidence to guide return to activity during the period of DFU remission. Therefore, a careful approach is re-

quired for gradual return to activity in order to reduce the risk of DFU recurrence and prolong ulcer-free, hospital-free, and activity-rich days for people in remission.<sup>9</sup>

for people with peripheral neuropathy to mitigate the risk of tissue injury and alter the properties of soft tissue.<sup>17</sup> However, finding the appropriate activity level that optimizes tissue loading but minimizes risk of injury during DFU remission remains an area with a lack of knowledge to guide clinical management. It is probable that activity can be

game-changer in changing outcomes for patients.

## Foot Monitoring in the Home Environment During Remission

Advancements in remote monitoring technologies have seen the development of several approaches to assist in the prevention of recurrence of foot ulcers.<sup>19,20</sup> These advancements may assist patients in identifying impending signs of deterioration and to seek care promptly to reduce delays in timely care.<sup>21</sup> For a long time, clinicians have relied on the use of clinical signs of inflammation or infection to detect a deteriorating foot, such as the presence of redness, pain, calluses, and edema.<sup>22</sup>

This concept remains relevant to this day in terms of evaluation of diabetes-related foot complications; there is now high-level evidence from several systematic reviews and a meta-analysis,<sup>13,23,24</sup> to suggest that the risk of tissue injury may be predicted by using digital infrared thermometry (skin temperature monitoring) as wound sites under the foot heat up before they break down.<sup>25</sup>

Typically, this involves an empowered patient monitoring foot temperatures once per day to identify early signs of foot inflammation. If there is a relative temperature difference detected above a certain threshold (usually a minimal difference of 1.4 degrees Celsius between corre-

*Continued on page 87*

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quired for gradual return to activity in order to reduce the risk of DFU recurrence and prolong ulcer-free, hospital-free, and activity-rich days for people in remission.<sup>9</sup>

The biggest barrier to addressing this paucity in evidence is the absence of an “activity threshold” to guide recommendations, which is likely going to be different for each individual patient in remission. Given the hiatus of activity observed during the active DFU period coupled with changes to ulcerated tissue recovering from injury, it is likely that there is decreased tolerance and loss of adaptation of the plantar tissues to loading in remission.<sup>16</sup>

Indeed, controlled stress when applied over time may be beneficial

incrementally increased or “dosed” using surrogate markers of inflammation such as the use of digital infrared thermometry or monitoring feet for clinical signs of inflammation as a guide for safe return to activity in people with recently healed DFUs.<sup>8,18</sup>

Current IWGDF guidelines suggest that in people at risk of foot ulceration, a small increase in the level of weight-bearing daily activity (~1,000 steps a day with a gradual 20% increase over time) does not seem to increase the risk of foot ulcer recurrence. However, this must be further evaluated in prospective, well-powered clinical trials. Return to activity is largely not considered in clinical guidelines but could be a

## *Physical Activity (from page 86)*

sponding foot sites), patients are advised to reduce ambulatory activity and to seek review of their foot by a foot care specialist such as a podiatrist. However, what is lacking from the literature was the concept of what to do with a rise in skin temperature and what specific advice should be given to patients and their caregivers.

In a recent controlled trial, the combination of skin temperature monitoring with activity modification (in the form of reduced physical activity and weight-bearing time) led to a 24% reduction in ulcer-recurrence or DFU at any foot site compared to standard care.<sup>26</sup> Therefore, activity modification coupled with foot temperature monitoring is a promising modality that is supported by current state of knowledge. Others have used a slightly

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different approach to foot monitoring using an intelligent insole system, comprised of a smart-insole with a very low sampling frequency (8 Hz) and a digital display watch worn by the patient to warn of impending risk of tissue injury.<sup>27,28</sup>

Such pressure-sensing insoles can be placed underneath a patient's own orthotics or insoles and provide a warning on the digital display of the wrist-worn watch if a sustained high pressure (but not peak plantar pressure) is experienced during use.<sup>28</sup> Using such an approach of providing continuous personalized feedback during daily activities over an 18-month observation period, reductions in plantar pressure (a precursor to DFU) and a learning response from participants following approximately four months of use was noted.<sup>2,8</sup>

Most importantly, the risk of DFU recurrence during the same period was reduced by up to 71% by using such an approach and by up to 86% in those using the device daily.<sup>27</sup> Therefore, where available, such technologies can supplement good clinical evaluation and intervention by podiatric physicians<sup>29</sup>, and the daily checking of feet by the patient and caregivers at home in detecting impending signs of DFUs. Likewise, these technologies could be used for activity dosing as a surrogate marker of inflammation when a foot heats up before it breaks down.<sup>25</sup>

## **Mitigating the Effect of Plantar Pressures During Ulcer Remission**

There are several aspects to prescribing pressure off-loading in the person in DFU remission given plantar pressures remain elevated in people with a history of DFUs even after ulcer healing.<sup>30</sup> Firstly, what is the

*Continued on page 88*



## Physical Activity (from page 87)

least invasive method to obtain the best off-loading outcome? Secondly, can externally applied off-loading techniques such as insoles, footwear, and other devices be modified to reduce plantar pressure and mitigate the risk of recurrence for the individual patient? Thirdly, can physical therapy or other modalities be used to improve the biomechanical function of the foot in remission? And lastly, is there the requirement for an internally applied off-loading approach such as a minor surgical procedure? The consideration of each off-loading approach is an important aspect of managing the foot in remission.

There is high level evidence from several controlled trials to support the use of off-loading footwear and insoles during foot ulcer remission with a novel meta-analysis showing that this leads to a 50% reduction in the risk of recurrence.<sup>24</sup>

Physical therapy can make a considerable contribution to off-loading. A tailored exercise program incorporating aspects of fitness, strength, range of motion, balance, and mobility may contribute to improved clinical outcomes.<sup>31</sup> However, there is still insufficient evidence to demonstrate a healing benefit of using non-weight bearing exercise as an intervention to improve healing.<sup>11,32</sup> Despite this, there is a recommendation from the IWGDF that foot and mobility-related exercises aimed at decreasing plantar pressure and improving range of motion with the aim of improving

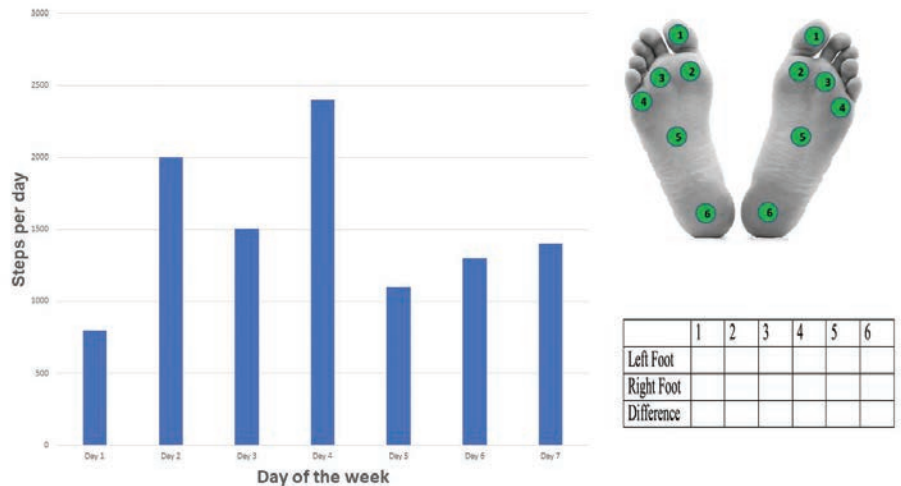


Figure 2: Example of daily activity tracking and a foot temperature monitoring log  
 Legend: On the left is an example of step count monitoring over seven days plotted on a bar graph with the x-axis representing days of the week and the y-axis steps per day. On the right is an example template that can be used to record temperature data at six foot sites daily by a patient.

**Based on preliminary data, we recommend a very cautious approach to return to activity with ~ 5,000 steps as an initial maximum step goal at the end of a five-week period of initial remission until better approaches have been developed.**

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neuropathy symptoms are likely to be beneficial, but with careful consideration of weight bearing activity in people at the highest risk of recurrence such as those with pre-ulcerative lesions.<sup>33</sup>

Other approaches to off-loading such as gait-retraining needs to be

evaluated in future studies given that people with DFUs have an impaired and altered gait strategy compared to those without DFUs.<sup>34,35</sup>

Current guidelines have reported no high-level evidence to support the use of such approaches at the present time.<sup>33</sup> Lastly, Buerger-Allen

exercises may have a vital role in improving foot perfusion in people with diabetes mellitus as shown with an improvement in ankle brachial pressures in a recent meta-analysis.<sup>36</sup> The clinical benefit and utility of this modality needs to be further evaluated in well controlled randomized trials

with clear inclusion criteria to evaluate which sub-group of individuals would most benefit from this and whether it can be effective in DFU remission.

We believe there is now good evidence to show that surgical off-loading techniques such as resection arthroplasty, osteotomy, tendon lengthening, gastrocnemius recession, and flexor tenotomy may be more beneficial to standard care alone in treating people with biomechanical impairments contributing to DFUs.<sup>37</sup> However, as per International Guidelines, these techniques should only be used where non-surgical off-loading has failed to redistribute pressure from a site.<sup>38</sup> For example, in people with diabetes and a neuropathic plantar metatarsal head ulcer, Achilles tendon lengthening, metatarsal head resection(s), or joint arthroplasty may be considered.<sup>38</sup> Likewise, in a patient

*Continued on page 89*

## *Physical Activity (from page 88)*

with a plantar or apex digital ulcer, digital flexor tenotomy may be considered.<sup>38</sup>

### **A Patient-Centered Approach to Activity Dosing**

There is a need for a patient-centered approach to activity dosing.<sup>39</sup> The process of returning to activity involves the implementation of the best possible pressure off-loading for the individual patient, coupled with temperature or pressure monitoring and daily inspection of the foot at home, and using an electronic device to monitor daily steps. There is evidence to show that consumer-wearable activity trackers, electronic devices used for monitoring fitness and other health-related metrics, can be valid and suitable for monitoring step-counts.<sup>40</sup>

Therefore, the process of return to activity should also be implemented in partnership with a physical therapist who can continue to follow-up the patient during remission for monitoring of physical activity and dosing changes and considering the patient's goals, preferences, and limitations.

Given the substantial additional workload for the patient and added burden of self-care, the conversation regarding return to activity should encompass an accurate estimate of the individual's risk of DFU recurrence, off-loading strategies described above, the equipment required—such as a digital infrared thermometer or activity monitor available to the patient—and the determination of individual patient goals related to physical activity.

Subsequently, a timeline regarding gradual return to activity should be considered when pressure off-loading has first been optimized using the above-mentioned modalities. Given the highlighted limitations in evidence, a set of patient recommendations have been developed based on best available evidence, patient perspectives, and expert opinion that can be utilized by clinicians to educate patients and caregivers to ensure the safe transition to footwear and return to activity following DFU healing to avoid recurrence (Figure 1).<sup>8</sup>

The proposed algorithm ensures a period of safe return to new footwear and insoles prior to the incremental dosing of activity based on a patient-specific target over the course of at least five weeks.<sup>8</sup> Based on preliminary data, we recommend a very cautious approach to return to activity with ~5,000 steps as an initial maximum step goal at the end of a five-week period of initial remission until better approaches have been developed.<sup>8</sup> Whenever there is a sustained rise in foot temperature, or the formation of a callus or an area of ongoing erythema or inflammation (over at least two consecutive days), we recommend reducing activity levels and the prompt review by a podiatrist (Figure 2).

These recommendations are general, and one must allow for flexibility and close inter-professional communication within the interdisciplinary team including the patient (and their caregivers) to co-design their plan on return to activity. This will support patient empowerment, an essential component of DFU care success and greatly aid in secondary prevention of recurrence.

*Continued on page 90*



*Physical Activity (from page 89)*

## Conclusions

Foot ulceration due to diabetes continues to leave a global footprint in healthcare burden and adversely affect the quality of life of those impacted. A shared-treatment goal between the interdisciplinary treating team including the patient (and caregivers) should be to reduce DFU recurrence yet prolong ulcer-free, hospital-free, and activity-rich days for people in DFU remission. Here, we report on some recent developments related to the importance of considering gradual return to physical activity and how interdisciplinary management may play a role in this important yet overlooked concept in caring for the patient during DFU remission. **PM**

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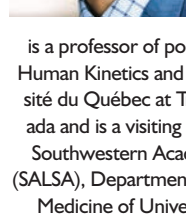
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