

Review - Basic and Applied Anatomy

# Management of daily physical activity and diabetic foot prevention

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## Abstract

Even if physical activity plays a key role within diabetic foot treatment its use and the results obtained from this treatment seem to be still limited. Nowadays, new and even more advanced technologies for the long term daily physical activity monitoring are available and they are radically changing some aspects of physical activity such as its amount, features and monitoring. In spite of the past, the several electronic devices that are currently available can be integrated into routine care and provide essential information for management to both the healthcare providers and patients. In particular, since the end of the last century, an increasing number of studies have applied the movement monitoring to patients at risk or with history of ulceration. The questionnaires have been progressively replaced with modern technologies such as accelerometers or complex multisensory devices able to objectively measure the physical activity performed. The data collected through the use of such devices can allow a better assessment of patient's condition and provide useful information for the definition of a more complete treatment protocol. Daily physical activity monitoring devices provide to the Diabetes Units information on the typology, quantity, distribution and intensity of the daily physical activity performed by each patient concurring to the prevention of foot ulcers that represent the most dreadful diabetes complications. The different functions and modes of operation of monitoring devices can be integrated to provide a more comprehensive and intelligent monitoring system that provide valuable information on patients' ongoing health status and the physical activity performed during daily life. These devices can manage in real time or even in remote the physical activity performed in addition to calculate that to be performed in the following hours. As a result, they contribute to improve patients' lifestyle and reduce the costs for the treatment of such complications. The aim of this review is to define and emphasize the role of a long term daily physical activity monitoring in the prevention of diabetic foot ulcers.

## Key words

Diabetic foot prevention, daily physical activity, life style, accelerometer, movement monitoring, exercise.

## Introduction

Diabetes mellitus (DM) is a metabolic disorder that causes mortality and morbidity whose incidence is increasing faster than in the past and it has been estimated that by 2035 over 500 million people will be affected worldwide (Guariguata et al.,

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2014; NCD Risk Factor Collaboration, 2016). Sedentary and incorrect lifestyle negatively affect patients with diabetes, inducing the occurrence of chronic complications in addition to hinder their treatment (Brazeau et al., 2008; Healy et al., 2008; Colberg et al., 2010). Of the long-term complications that can affect DM patients, diabetic foot ulcers are the most ominous and dreaded, since they affect not only the patient's mobility and overall well-being, but they can increase morbidity and mortality (Apelqvist et al., 2008; van Schie, 2008; Bakker et al., 2016).

The yearly incidence of diabetic foot ulcer in the DM population is around 4% in developed countries and even higher in developing countries while the lifetime risk of a patient to develop a foot ulcer is about 25% (Prompers et al., 2008; Bakker et al., 2016).

The complexity of the multifactorial pathogenesis of diabetic foot ulcer makes difficult its prevention (Pound et al., 2005; Prompers et al., 2008; Apelqvist, 2012). The timely consideration of this complexity plays a key role in guaranteeing proper treatment through physical activity (figure 1). It is well known that physical activity is a milestone in patient therapy aimed at achieving metabolic control and prevention of the major diabetes complications (Balducci et al., 2006, Smith et al., 2006; Colberg et al., 2010; Kluding et al., 2012; Vinik, 2016).

In this article "physical activity" means body movement generated by muscle contraction while "exercise" means physical activity aimed at improving fitness or functional/motor deficits. Unstructured physical activity means "non-exercise" or daily life activities (Colberg et al., 2010; Umpierre et al., 2011, Colberg, 2017). Structured and unstructured physical activity can be performed in an adapted and scheduled way in order to prevent diabetic foot.

Innovations in electronic healthcare are revolutionizing the involvement of both specialists and patients in the modern healthcare system by extending the capabilities of monitoring devices (Appelboom et al., 2014).

These devices have the potential to change the way healthcare is currently being managed. Moreover, healthcare information exchange will make it easier for any diabetes service provider to access the relevant information and provide better and informed point-of-care solutions (Baig et al., 2017).

The aim of this review is to arouse specialists' attention on the role of the proper long term daily physical activity monitoring and management as preventive measures against diabetic foot ulcers.

## **Daily Physical Activity Monitoring (DPAM) and foot ulcer prevention**

Patients monitoring systems are emerging as effective tools for the prevention, early detection and management of chronic conditions as those induced by diabetes mellitus.

These devices are able to continuously monitor free-living patients and consequently expedite treatments. They are easily managed and are becoming increasingly accurate and reliable for patient care (Appelboom et al., 2014; Baig et al., 2017).

Among wearable patient monitoring systems, physical activity performed can be evaluated by pedometer, accelerometers, and gyroscopes (Maluf and Mueller, 2003; Armstrong et al., 2004; Appelboom et al., 2014; Brazeau et al., 2015; Majumder et al., 2017).

The different systems and monitoring techniques can be integrated to provide a more comprehensive system for measuring other parameters (i.e. body-temperature, posture, etc...) as modern complex monitoring systems have already provided (Mathie et al., 2004; Waaijman et al., 2013; Dasanayake et al., 2015; Baig et al., 2017).

Daily physical activity monitoring could play an important role in diabetes management even for those patients affected by foot ulcer and it can positively affect several aspects of diabetes disease: from glycemic control to foot plantar pressure. The data collected on the daily physical activity performed allow the improvement of patient's treatment through a proper organization and management of structured or unstructured physical activity (Maluf and Mueller, 2003; Armstrong et al., 2004; Lim et al., 2015; Ding and Schumacher, 2016).

### Daily physical activity monitoring and major diabetes-induced risk factors

A first key step in preventing diabetic foot is the timely knowledge and management of all major risk factors in addition to an accurate clinical picture of each patient.

Diabetic foot lesions frequently occur in patients who show two or more risk factors (Apelqvist et al., 2008). Diabetic peripheral neuropathy and peripheral vascular disease negatively affect mobility and a patient's quality of life (Prompers et al., 2008; van Schie, 2008; Francia et al., 2014; Vinik, 2016). More than half of patients with type 2 DM are affected by diabetic peripheral neuropathy, that can progressively induce motor dysfunction preceded by sensory deficits (Balducci et al., 2006; Smith et al., 2006; Apelqvist, 2012; Kluding et al., 2012; Vinik, 2016).

The neuromuscular problems (i.e. muscle weakness, reduced endurance, and loss of coordination) that may occur in patients with diabetes can worsen or lead to abnormalities in the biomechanics of the foot and of the whole body, in dynamic as well as static postures (Mueller et al., 1994; Uccioli et al., 1995; Francia et al., 2014, 2015; Sartor et al., 2014; Toosizadeh et al., 2015). These impairments can also result in abnormal foot rollover and plantar pressures which significantly increase the risk of painless foot ulcer (Sawacha et al., 2009; Apleqvist, 2012; Francia et al., 2014). In these patients the use of DPAM can help specialists to define a proper exercise therapy protocol indicated for daily life.

In addition to diabetic peripheral neuropathy, even peripheral arterial disease plays an important role in the development of foot ulcers, and can also negatively affect healing (Apelqvist et al., 2008; Bakker et al., 2016). It has been observed that about 50–60% of all diabetic foot ulcers are ischemic or neuroischemic (Prompers et al., 2008). This condition can induce different functional limitations: minor gait speed and walking distance, resting pain, and claudication (Stewart et al., 2002; Collins et al., 2011; Francia et al., 2014). However, even in the presence of this complication, DPAM can help provide better patient management.

The presence of foot deformities and the importance of avoiding foot and leg trauma are other major risk factors to be considered in the physical activity management of diabetic patients (Apelqvist et al., 2008; Apelqvist, 2012; Bakker et al., 2016; Anichini et al., 2017).

Today it is known that general joint mobility of the lower limbs, usually evaluated at the ankle and foot joints (subtalar and first metatarsophalangeal), can signifi-

cantly decrease in subjects with diabetes (Delbridge et al., 1988; Francia et al., 2017). It is even known that limited joint mobility can contribute to the development of foot deformities, and these structural abnormalities may be harmful and trigger abnormal forces on the foot's plantar surface (Fernando et al. 1991; Zimny et al. 2004; Francia et al., 2017).

It has been demonstrated that targeted exercise therapy protocols can improve muscle strength, joint mobility, flexibility, and balance, in addition to abnormalities in gait speed and walking distance (Anichini et al., 2005; Allet et al., 2010; Morrison et al., 2010; Song et al., 2011; Sartor et al., 2014; Francia et al., 2015). Likewise, the proper management of daily life activities can help overcome some limitations connected to the physical activity practice such as the patient's vulnerability and limited compliance, difficulty in performing the protocols routinely and for prolonged periods, feelings of tiredness, and the fear of hypoglycemia (Thomas et al., 2004; Brazeau et al., 2008; Francia et al., 2014; Lim et al., 2015; Ding and Schumacher, 2016). In this context, DPAM can monitor and help manage the patient's lifestyle, their physical activity and other things such as their adherence to medical prescriptions (Waaajman et al., 2013).

#### Daily physical activity monitoring and foot plantar pressure management

Physical activity is paradoxically an important element of therapy but, at the same time, stressful for feet. The early studies of this paradoxical "risk factor" focused on analyzing gait quality and foot plantar pressures. Consequently, during the 20th century, and especially at the end of the 1970s, the importance of investigating the qualitative or quantitative aspects of human movement for the prevention of foot ulcers has aroused more attention (Stokes et al., 1975; Ctercteko et al., 1981; Cavanagh et al., 1993; Sawacha et al., 2009). The assessment of daily life physical activity performed by patients with and without risk of diabetic foot ulcer has been carried out by different methods (questionnaires, pedometer and accelerometer; Table 1). The use of even more advanced sensors and systems for the assessment of DPAM started to be applied to diabetic foot units since the current century (Table 1) (Armstrong et al., 2001a; Armstrong et al., 2001b; Maluf and Mueller, 2003; Lemaster et al., 2003).

The DPAM of daily life style can be of great importance for its possible correlation with the total plantar pressure exerted on the feet. It can also highlight potentially harmful lifestyles such as those tending to concentrate or increase plantar foot stresses up to a dangerous degree, and help patients to modify their daily lifestyle in order to prevent ulcers (Armstrong and Boulton, 2001; Armstrong et al., 2004; Kshamata et al., 2012).

This estimation on long period can be nowadays possible considering together the results of DPAM and the patients foot pressure in static and dynamic conditions evaluated by the use of devices as baropodometry, in-shoe pressure sensors or instrumental walkways with a force platform (Table 1) (Maluf and Mueller, 2003; Kanade et al., 2006; Kshamata et al., 2012; Sawacha et al., 2009).

#### The "Three cornerstones" of physical activity management

Supervised exercise therapy can be important at the beginning of treatment in patients at higher risk of ulcer for the improvements that allows achieving in balance,

**Table 1.** Studies on the use of daily physical activity monitoring (DPAM) in diabetes settings; key to abbreviations at the end of table.

Study (year)	General purpose	Study type	Sample size	Duration and equipment	Results and conclusion
Armstrong et al. (2001b)	To compare the effectiveness of three off-loading modalities to heal neuropathic foot ulcerations	Prospective longitudinal study	63 patients with DM and plantar foot ulcers	12 weeks. Pedometer	Patients treated with total-contact casts were significantly less active than those treated with half-shoe. There was not a significant difference in activity between patients treated with the total-contact casts and those treated with the removable cast walkers
Armstrong et al. (2001a)	To evaluate the magnitude and location of patients activity level	Prospective longitudinal study	20 DM patients at high risk	1 week. Activity monitor	Patients were most active during late morning and mid-afternoon hours. At home the patients used the physician-approved shoes less than outside home
Maluf and Mueller (2003)	To compare the amount of weight-bearing activity and estimate of cumulative plantar tissue stress	Cross-sectional study with matched groups	20 DPN patients with and without history of foot plantar ulcer, 10 non-diabetic control subjects	1 week. Two-dimensional accelerometers and in-shoe pressure measurement	Patients with diabetes and a history of previous ulcers may be susceptible to plantar tissue injury even at relatively low levels of cumulative tissue stress
Lemaster et al. (2003)	To determine whether weight bearing activity increased the risk of foot ulcer	Prospective longitudinal cohort study	400 patients with DM and a prior history of foot ulcer	2 years. 24-h activity questionnaire	Increased weight-bearing activity did not increase the risk of foot re-ulceration
Armstrong et al. (2004)	To evaluate the role of activity in the development of neuropathic foot ulceration	Prospective longitudinal study	100 DM patients at high risk	>25 weeks (or until ulceration). Accelerometer/ pedometer	Patients with diabetes who develop ulceration may actually have a lower overall daily activity than their non ulcerated counterparts, but the quality of that activity may be more variable

Study (year)	General purpose	Study type	Sample size	Duration and equipment	Results and conclusion
Kanade et al. (2006)	To explore plantar loading of the surviving foot following unilateral trans-tibial amputation	Cross-sectional study with matched groups	21 patients with DPN and trans-tibial amputation; 21 patients with DPN without history of ulceration	8 consecutive days. Stepwatch Activity Monitor and in-shoe pressure measurement system	Adaptations in gait and level of walking activity affect the plantar pressure distribution and ultimately the potential risk of ulceration to the surviving foot
Najafi et al. (2010)	To monitor spontaneous daily physical activity and examine both walking and standing activities	Prospective longitudinal study	13 patients with DPN	2 days. Body-worn sensor	Patients with DPN spent 13.5% of time in standing and 6.1% in walking. Walking may cover little of a person's daily physical activity and hence might not be representative of what the subject is doing during daily life activities
Van Schie et al. (2011)	To evaluate the validity of the Step Activity Monitor for assessing physical activity and the relation with the self-reported physical activity.	Prospective longitudinal study	24 patients with DPN	2 days. Step Activity Monitor, Step Watch 3, and International physical activity Questionnaire	Step Activity Monitor was shown to be a valid tool to assess physical activity
Waaijman et al. (2013)	To objectively assess adherence to wearing prescribed custom-made footwear	Randomized controlled trial	107 DPN patients with a recently healed plantar foot ulcer	7 consecutive days. Temperature-based monitor and ankle-worn activity monitor	Adherence to wearing custom-made footwear is insufficient, particularly at home where patients exhibit their largest walking activity. This low adherence is a major threat for reulceration

Study (year)	General purpose	Study type	Sample size	Duration and equipment	Results and conclusion
Lim et al., (2015)	To investigate the effect of an individualized multidisciplinary u-health care service combined with exercise monitoring and dietary feedback on glucose control	Randomized controlled trial	100 T2DM patients assigned to a self monitored blood glucose group or u-healthcare group	6 months. Glucometer and an activity monitor that automatically transferred test results to a hospital-based server	The HbA <sub>1c</sub> level was significantly decreased in the u-healthcare group compared with the self monitored blood glucose group
Brazeau et al. (2015)	To determine if there was an inverse relationship between sitting and step counts in a diabetes cohort	prospective cohort study	The cohort included 198 T2DM adults	14 days. Pedometer, International physical activity Questionnaire	There was a low correlation between sitting time and step counts
Dasanayke et al. (2015)	To develop a method to detect the onset and end of exercise	Research study	16 adults with T1DM	2 days. Diary, accelerometer, heart rate monitor, and continuous glucose monitor	The method identified the onset and end of exercise in approximately 5 minutes, with an average blood glucose change of only -6 mg/dL
Kluding et al. (2017)	To determine the impact of an intense lifestyle intervention on neuropathy progression and quality of life	Randomized controlled trial	140 type 2 DM patients with peripheral neuropathy	18 months of supervised exercise training, 7 day of actigraphy based counseling to reduce sedentary behavior	An intensive lifestyle intervention may be a sustainable, clinically effective approach for people with DPN that improves patients outcomes and can have an immediate impact on patient care
Jao et al. (2017)	To evaluate the accuracy of two physical activity monitors	Cross-sectional study	31 patients with history of foot ulcer	14 weight-bearing and non-weight-bearing activities. Two physical activity monitors	There was an important difference in accuracy of weight-bearing activities between the physical activity monitors.

DFU: diabetic foot ulcer; DM: Diabetes Mellitus; DPN: diabetic peripheral neuropathy; GPS: Global Positioning System; HbA<sub>1c</sub>: glycated hemoglobin; T1DM: type 1 diabetes mellitus; T2DM: type 2 diabetes mellitus; u-healthcare: ubiquitous healthcare.

strength and gait (Goldsmith et al., 2002; Allet et al., 2010; Morrison et al., 2010; Sartor et al., 2014). During exercise therapy periods, the patient's functional abilities and quality of movement should be checked (as well as lifestyle changes) so that instructions can be promptly adapted according to the new needs identified. These evaluations should be periodically repeated according to the patient's needs (Otterman et al., 2011; Sartor et al., 2014; Francia et al., 2015).

It is important to underline that all due precautions must be taken in the management of a patient's daily physical activity designed to prevent the occurrence or facilitate the recovery of risk factors for ulcers (Otterman et al., 2011; Francia et al., 2014; Kluding et al., 2015).

Besides leg trauma and falls, the disuse/overuse of muscles and connective tissues must be avoided (Abate et al., 2013; de Jonge et al., 2015). The abnormal balance, posture and gait biomechanics that patients at risk can exhibit, in addition to the presence of foot deformities, may lead to overuse of some lower limb structures (i.e. muscle and connective tissue) while others cannot be involved during daily physical activity and undergo disuse (Francia et al., 2014; de Jonge et al., 2015). In particular, the overuse of the foot and leg structures (i.e. Achilles tendon or plantar fascia) is especially feared because it can contribute to the development of foot ulcer (Giacomozzi et al., 2005; de Jonge et al., 2015).

Once again, the results of postural and gait analysis can provide useful information on the management of daily physical activity. It is important to assess the at-risk patient's muscle strength, joint mobility, balance and posture, as carried out in some studies, and to manage daily physical activity considering further functional deficits, by directing it to the prevention of ulcers.

Such management of the "three cornerstones" of physical activity (long term physical activity monitoring, posture-gait analysis and muscle strength/joint mobility assessments) may ensure that the results achieved by an exercise therapy program are more long-lasting in patients (Figure 1).

#### Daily physical activity monitoring and glycemic control

Diabetic foot prevention begins with proper care of the patient at the time of diagnosis through treatment aimed at achieving good metabolic control (figure 1). Most treatment involves patient education sessions on the role and importance of an active lifestyle (Colberg et al., 2010; Umpierre et al., 2011). However, as well as nutrition, even physical activity can induce considerable variations in glycemic levels in patients with diabetes. This effect can limit metabolic control, and become a barrier to exercise, especially in patients with type 1 diabetes, making physical activity a risk factor for glycemic control (Brazeau et al., 2008; Colberg et al., 2013). One goal to pursue in the management of a patient's physical activity is to improve blood glucose control in addition to a better peripheral insulin action and improvement in the body mass index (Colberg et al., 2010, 2015; Umpierre et al., 2011).

If on the one hand, in order to maintain glycemic control, a balance between insulin dosage and food intake is required to maintain a proper glycemia during and after physical activity (Loprinzi et al., 2013; Colberg et al., 2015), on the other hand, the type and duration of the ensuing physical activity can be defined for pursuing this goal (Francia et al., 2018).

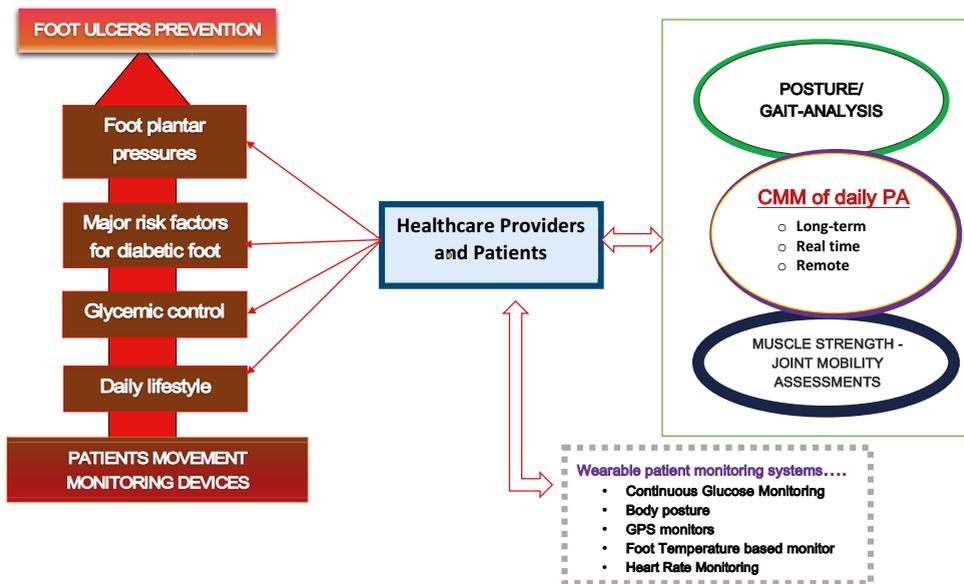
**Table 2.** Pros and cons of Daily Physical Activity Monitoring (DPAM).

Pros	Cons
Being informed of the lifestyle and daily physical activity performed	Device availability and limitations
Estimate foot plantar pressure and its daily distribution	Time and cost for processing the data collected
Monitoring of the effects of the interventions carried out	Patient’s compliance: <ul style="list-style-type: none"> <li>- Willingness to wear the device for enough time and repeat the evaluation several times if necessary</li> <li>- Does not change his/her own lifestyle during the monitoring</li> <li>- Fills in a log book to record activities and also those performed without wearing DPAM systems - Synchronizes the devices for remote monitoring</li> </ul>
Remote patient monitoring	Knowing patient’s functional, postural and movement characteristics before modifying daily lifestyle
Being aware of seasonal and daily variations of physical activity level	Differences in the results achieved by different devices
Multi-parametric monitoring	Limitations in the accurate recognition of each kind of complex movement (small steps, cycling, etc.)  Indirect evaluation of foot plantar pressure  Type of activities not allowing the use of DPAM devices (i.e. immersions)

Daily physical activity monitoring means that patients with diabetes have to be informed about physical activity performed and provides indications about what is to be performed calculated on the basis of data collected during long term monitoring. As a result, patients are more aware of managing appropriate food-liquid intake and/or drug therapy to achieve good metabolic control (Armstrong and Boulton, 2001; Colberg et al., 2013; Kluding et al., 2017).

It has also been suggested that the evaluation of physical activity performed between main meals, in addition to that during 24 h, can enable patients to better orient themselves in their choices regarding glycemia management (Francia et al., 2016). The use of devices for the continuous monitoring of glycemia or carbohydrate intake adds useful information to patients and specialists for the management of DM (Armstrong and Boulton, 2001; Lim et al., 2015; Ding and Schumacher, 2016; Colberg, 2017).

However, specialists and the ensuing patients must be aware that vigorous or prolonged physical activity may have significant acute effects on glycemic fluctuations encountering difficulties in their management (Colberg et al., 2013; Yardley et al., 2013). In comparison to structured physical activity, daily life movement can usually be performed at light or moderate intensity so as not to excessively modify blood



**Figure 1.** “Three cornerstones” for the prevention of diabetic foot ulcer. DPAM (daily physical activity monitoring) provides targeted intervention at several levels (footplantar pressure, glycemic control and other major risk factors of diabetic foot) aimed at preventing the development of foot ulcers.

glucose values (Umpierre et al., 2011; Yardley et al., 2013). The improvement in glycemic control over time can be attained with DPAM, with knowledge of the type, duration, intensity, and distribution of the activity performed. Each of these parameters can be set up or modified in order to achieve proper glycemia (Armstrong and Boulton, 2001; Colberg et al., 2013; Ding and Schumacher, 2016).

## Discussion

The complex etiopathogenesis of diabetic foot ensures that to date the role played by exercise therapy in the primary or secondary prevention of foot ulcers is not yet fully understood.

It has been demonstrated that most of the motor and functional deficits in DM patients significantly improve after short exercise therapy training periods and can achieve almost the level of healthy control group performance (Dijs et al., 2000; Allet et al., 2009; Nicolucci et al., 2012; Francia et al., 2015).

Patients can perform most of these activities as home-based exercise programs (Dijs et al., 2000; Collins et al., 2001; Goldsmith et al., 2002; Sartor et al. 2014) including weight-bearing and/or non-weight-bearing exercises according to the patient’s needs (Dijs et al., 2000; Allet et al., 2009; Mueller et al., 2013). However, to date, little attention has been paid to the role of exercise in the prevention of postural and bio-mechanical deficits that can induce dangerous foot plantar pressure distribution (De

Leòn Rodriguez et al., 2013; Francia et al., 2014; Sartor et al., 2014).

The real preventive impact on foot ulcers of exercise therapy which is not systematically included in the treatment of patients with diabetic foot cannot be defined. In this context, information on the daily physical activity performed by patients can be useful within the preventive measures against foot ulcers (Maluf and Mueller, 2003; Van Schie et al., 2011).

Daily physical activity monitoring provides targeted intervention at several levels in the process leading to the development of foot ulcers in diabetic patients (figure 1). Starting from providing information for metabolic control, DPAM can also show the amount of daily stress exerted on the foot (Kanade et al., 2006; Connelly et al., 2013; Lim et al., 2015).

This approach may also be able to determine what constitutes an unhealthy lifestyle, seasonal changes in leisure-time or working hours in addition to the location of activities so as to enhance patient management. For a full comprehension of these parameters, it can be appropriate to repeat measurements several times a year (Pivarnik et al., 2003; Ding and Schumacher, 2016). Patients with diabetes could benefit from a continuous movement monitoring because the best way to monitor patient is through understanding their interaction with daily activities allowing them to continue monitoring themselves outside the hospital with an accurate assessment of the data collected (Appelboom et al., 2014).

Daily physical activity monitoring can help to evaluate the effect of protective foot devices since it provides information adherence to prescriptions in addition to all kinds of activities performed (Armstrong et al., 2001b; Waaijman et al., 2013). However, the use of devices for DPAM evaluations involves costs, not only for buying the equipment but due to the involvement of specialized personnel and time for processing the data collected (Table 2).

It is important that DPAM covers all 24 hours in at-risk patients. In fact, irregular monitoring can easily hinder data collection regarding the physical activity performed, since only a few minutes are needed to significantly modify the daily physical activity evaluation.

The use of modern devices can help overcoming the barriers to the diffusion of physical activity and reducing negative effects diabetes-induced to patients' attendance at sports or physical activities (Colberg et al., 2015).

Although patients cannot wear a device continuously, they can fill out a log book or diary to record the activities performed when the device is not worn. Special forms can help the patient to accurately register the activities performed (Armstrong et al., 2001b; Najafi et al., 2010; Dasanayake et al., 2015).

Drawbacks to the use of new technology for DPAM include the difficulty in assessing, understanding and managing the lifestyle of patients at risk. This may explain the currently limited use of such methods, despite their promising start (Armstrong and Boulton, 2001; Armstrong et al., 2001a).

## Conclusions

The proper management of daily life activities, well-organized in quantity, intensity, type, and distribution, monitored by the use of new DPAM devices, can be a

winning element in showing the potentialities of physical activity in the treatment of patients with diabetes. This approach can ensure better metabolic control, concur in the prevention and treatment of diabetic foot ulcers as well as give more opportunities for modifying the patient's lifestyle. The timely knowledge of each patient's health condition and his/her compliance, in addition to the cost, the time needed for processing data and information on the physical activity performed, are essential requirements for the diffusion of this management approach.

The reliability of patients monitoring by DPAM promotes a prevention-centered culture despite a widespread medicalization. Although the assessment of daily lifestyle in at-risk patients is still limited, the use of DPAM and functional tests following the protocol can provide valuable information for the definition of a more complete patients' assessment and development of care pathways.-

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