

# Analysis of Gait Characteristics Using a Dynamic Foot Scanner in Type 2 Diabetes Mellitus without Peripheral Neuropathy

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## Abstract

**Objectives:** The objective of the present study was to identify the gait changes in T2DM subjects without PN (Peripheral Neuropathy). **Methods:** 36 T2DM subjects without PN and 32 age matched non-diabetic subjects (NDM) were recruited. Gait characteristics were analyzed using Win-track dynamic foot scanner. Data were analyzed using independent 't' test. Level of significance was kept at P<0.05. **Results:** Analysis showed no significant differences in gait characteristics in T2DM subjects without PN as compared to NDM subjects. **Conclusions:** T2DM subjects without PN presents with a gait same as subjects without T2DM. Gait changes in T2DM are dependent on loss of protective sensation of the foot and intrinsic foot muscle atrophy. Therefore, dynamic foot analysis should be incorporated in routine diabetic foot evaluation to understand the gait in T2DM and hence many complications can be prevented.

## Introduction

Type 2 diabetes mellitus (T2DM) is a multi-system, metabolic disease

characterized by increased blood glucose and has become one of the major health troubles in the world (Wyatt & Ferrance, 2006). According to the International Diabetes Federation (IDF, 2013), the total number of people with diabetes in all age-groups worldwide was estimated to be 382 million in 2013 and expected to grow to 592 million by 2035. In India alone, it was anticipated to be about 65.1 million in 2013, and likely to rise to 109.0 million by 2035 (IDF, 2013).

In normal everyday life activities, lower limbs readily accommodate even and uneven surfaces. Efficiency to overcome all these daily activities depends on structural and operational ability of the lower limbs during walking (Baker, 2006). Normal walking consists of two phases, stance and swing. Stance phase is subdivided into three intervals (initial double stance, single limb support and terminal double support (Atkinson et al, 2005).

Peripheral neuropathy (PN) is the well-known diabetic complication attributed to chronic hyperglycemia (Bansal et al, 2014). Studies reported that T2DM subjects with PN are 15 times more prone to report injuries due to altered gait than T2DM subjects without PN (Bansal et al, 2014). Altered gait changes may contribute to various complications like callus formation, toe deformities and plantar ulcers where most of these users developed during walking (Richardson et al, 1992). Studies reported that gait changes and falls are dependent of PN and

this gait change does not usually occur until late diabetes and long duration after balance impairments seen (Muelleret al, 1989; Dingwell et al, 2000; Richardson, 2002). A study conducted by Petroskey et al (2005) reported that whatever the mechanism, subjects with diabetes presents deficits in gait before the objective loss of protective sensation in the feet (Brach et al, 2008). These contradictory studies underscore the fact that the movements of gait abnormalities in T2DM are not light and under debate.

Gait analysis plays a major role in diagnosis of functional locomotion impairments. Studies have utilized several methods like 3D gait analysis in a gait lab with high definition cameras and reflective markers, power plates, accelerometers to study the biomechanical characteristics of the gait in diabetic subjects (Katoulis et al, 1997; Richardson et al, 2004; Petrofsky et al, 2005). These methods involve a special gait lab, which is expensive and this process is time consuming and difficult to perform in routine clinical foot assessment. Looking at all these factors, the objective of the present work is to examine the gait characteristics using a dynamic foot scanner in T2DM with no PN.

## Materials & Methods

The present study was approved by the Institutional Ethical Committee (IEC). Thirty six type 2 diabetes mellitus subjects without peripheral neuropathy and 32 age matched healthy subjects were screened and recruited. A written informed consent

was obtained from all the subjects and detailed baseline clinical evaluations were done. Subjects without peripheral neuropathy, no foot deformities, foot ulcers and who were able to walk independently were included in the study. Subjects with hypothyroidism, retinopathy, musculoskeletal disorder and other neurological disease were excluded. Absence of peripheral neuropathy was confirmed by doing following clinical evaluations:

10g monofilament (5.07) testing: The sensory test was performed with the subject in supine lying and the result was recorded as absent, reduced or present depending on the subject's response. Vibration perception threshold (VPT): The vibration threshold was examined using Biothesiometer with the subject in supine lying and the result was recorded and 5mv-14mv is considered absence of peripheral neuropathy and 15mv-24mv is considered risk for developing peripheral neuropathy and above 25mv is considered presence of peripheral neuropathy.

Michigan Neuropathy screening instrument: During the examination, subject's foot was inspected for abnormalities in the foot. Each foot with any abnormality received a mark of 1. Each foot was also examined for ulcers and each foot with an ulcer received a score of 1. The ankle reflexes were elicited. If the reflex was present and it's scored as 0, the reflex designated as present with reinforcement and was scored as 0.5. If the reflex was absent and it was scored as 1.

Vibration sensation tested same as above mention in VPT. Vibration was scored as present if the subject was able to feel within 8Mv and scored as 0, if the subject was able to sense from 15mv- 24mv, he was given score of 0.5 and if the subject was not able to feel or feel in within an above 25mv he was given score of 1. The total potential score is 8 and, in the published score algorithm, a score  $\leq 2.5$  is considered absence of peripheral neuropathy, score of 2.5-4 is considered risk for developing peripheral neuropathy and above 4 is considered presence of peripheral neuropathy.

Dynamic gait analysis: Gait characteristics analysis was performed using Win-Track (MEDICAPTEURS Technology France) – Dynamic foot scanner. The win - track consisted of a 4m long walkway and a data processing system that checked the dynamic scanner through software. Test procedures were demonstrated and made familiar to all the subjects. Subjects were instructed to look ahead and walk on the platform at a comfortable speed. The data were transmitted to the computer through win-track software for analysis. SPSS version 16.0 for windows was used for data analysis. Normality test was held out and independent 't' test was employed to determine the difference between the groups. Level of significance was kept at  $P < 0.05$ .

## Results

In the present study, a total of 68 subjects (47 males and 21 females) were included. 36 type 2 diabetes mellitus

subjects without peripheral neuropathy had a mean age of  $(48.22 \pm 8.163\text{yrs})$ , mean BMI  $(24.15 \pm 2.49)$  and Mean duration of type 2 diabetes mellitus was  $9.39 \pm 5.05$  yrs. 32 non diabetic subjects

had a mean age of  $(48.59 \pm 12.33\text{yrs})$ , mean Body Mass Index  $(24.07 \pm 3.80)$  as presented in Table 1.

**Table 1. Descriptive characteristics of T2DM subjects with no PN and NDM subjects.**

	Group	N	Mean $\pm$ SD
Gender	Males	47	
	females	21	
Age (years)	T2DM with no PN	36	$48.22 \pm 8.163$
	NDM	32	$48.59 \pm 12.33$
BMI	T2DM with no PN	36	$24.15 \pm 2.49$
	NDM	32	$24.07 \pm 3.80$
Duration of Diabetes	T2DM with no PN	36	$9.39 \pm 5.05$

T2DM: Type 2 diabetes mellitus, PN: peripheral neuropathy, NDM: Non diabetes mellitus, BMI: Body mass index

**Table 2. Comparison of gait parameters between T2DM subjects without PN and NDM subjects.**

Parameters	T2DM with no PN (mean $\pm$ SD)	NDM subjects (mean $\pm$ SD)	95% Confidence	p-value
			Interval (lower, upper)	
Step duration Right	$600.28 \pm 164.95$	$646.22 \pm 224.36$	-140.59, 48.70	0.336
Step duration Left	$636.89 \pm 199.88$	$694.69 \pm 221.50$	-159.81, 44.22	0.262
Step length Right	$498.47 \pm 198.45$	$528.88 \pm 114.53$	-110.17, 49.37	0.449
Step length Left	$498.58 \pm 210.80$	$502.94 \pm 147.56$	-93.52, 84.81	0.923
Gait cycle length Right	$866.58 \pm 241.43$	$947.75 \pm 194.37$	-186.83, 24.49	0.130
Gait cycle length Light	$906.28 \pm 196.23$	$980.78 \pm 165.20$	-162.05, 13.04	0.094
Gait cycle duration	$1220.00 \pm 265.51$	$1253.59 \pm 237.69$	-156.23, 89.04	0.586
Stride duration	$1774.72 \pm 240.24$	$1680.94 \pm 327.60$	-44.28, 234.80	0.180

T2DM: Type 2 diabetes mellitus, PN: peripheral neuropathy, NDM: Non diabetes mellitus.

Gait characteristics of T2DM subjects without PN and NDM subjects are summarized in Table 2. During walking, T2DM without PN group showed no difference in all the gait characteristics compared to NDM subjects, step duration (right  $p=0.336$ , left  $p=0.262$ ), gait cycle length (right  $p=0.449$ , left  $p=0.923$ ), gait cycle duration ( $p=0.586$ ), stride duration ( $p=0.180$ ) compared to NDM subjects.

## Discussion

In the present study, gait characteristics were analyzed in T2DM subjects without PN. Result analysis showed no change in the gait characteristics in T2DM subjects without PN as compared to NDM subjects.

Several studies have documented that subjects with type 2 diabetes mellitus with

peripheral neuropathy report altered gait characteristics (Richardson *et al*, 1992; Muelleret *al*, 1989; Dingwell *et al*, 2000). The possible mechanism for altered gait characteristics with peripheral neuropathy could be due to several causes. The loss of proprioception, sensory loss and intrinsic foot muscle weakness occurs in later phases of diabetes mellitus that lead to changes in gait characteristics (Brach *et al*, 2008; Katoulis *et al*, 1997; Richardson *et al*, 2004).

Very few studies documented that type 2 diabetes mellitus subjects without peripheral neuropathy report altered gait. A survey led by Petrofsky *et al* (2005) found a reduction in gait characteristics like step duration and step length walking on a floor surface. But the limitation of this work was, their study was conducted on older age group. The gait changes observed can be immediately linked to ageing. Sawacha *et al* (2009) conducted a survey to investigate gait changes in T2DM without PN and reported that these gait changes can be due to somatic motor and vestibular changes associated with T2DM. The mechanism of impairment to the vestibular, autonomic and somatic system has been considered to be due to compromised microcirculation associated with poor glycemic control in T2DM. Vestibular system in the internal ear is highly vascularized but in diabetes mellitus due to altered microcirculation an oxygen and nutrient supply is decreased, which affects somatic and autonomic reflexes leading to altered gait in T2DM

without PN. Damage to the vestibule, somatic and autonomic system occurs over a period of time, which is dependent on duration of diabetes mellitus and it is proved that longer the duration of diabetes and uncontrolled diabetes higher the chance of presenting with peripheral neuropathy and altered gait. However, in the present study, we didn't find any alteration in the gait in T2DM subjects without PN. This can be due to gait alterations are independent of the loss of protective sensation in the feet, atrophy of the intrinsic foot muscles, damage to vestibular, somatic and autonomic system occurs over a period of time and depends upon how the diabetes mellitus controlled and managed. Gait alteration can be seen in T2DM subjects with uncontrolled blood sugar levels, which diminishes the microcirculation by a damaging peripheral nervous system which includes somatic and autonomic and vestibular system leading to altered gait.

All the studies which reported on gait characteristics have used sophisticated gait labs which consists of 3D cameras and sensors on the body at the joint levels and electromyography to record the muscle activity. This may not be possible in routine clinical diabetic gait evaluation because it is expensive and time consuming. Hence, in our study, we employed a simple, cost effective and easy to perform tool Win-track (MEDICAPTEURS Technology France) – Dynamic foot scanner to analyze gait

characteristics and can be performed in routine clinical diabetic gait analysis.

**Conclusion:** Gait changes observed in diabetes mellitus subjects are dependent on loss of proprioception, loss of protective sensation in the feet and weakness of the intrinsic foot muscles which occurs in later phases of diabetes mellitus depends upon duration of diabetes and how blood sugar levels are controlled. In regular clinical foot assessment dynamic foot scanner can be employed to evaluate gait, as it is not time consuming and doesn't need a separate clinical lab for the valuation. Therefore, we recommend using a foot scanner as one of the tools in the comprehensive clinical foot evaluation for screening patients with diabetes mellitus.

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Conflict of Interest None Declared