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Comparison of Neurodynamic Examination Findings in Normal Subjects, Type-2 Diabetes Mellitus Subjects, Painless Diabetic Peripheral Neuropathy and Painful Diabetic Peripheral Neuropathy

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ABSTRACT

Background and purpose: Neurodynamics is the concept based on a close interaction of mechanics and physiology of the nervous system which is to be considered while assessing and treating patients via nervous system mobilization and manual therapy. Neurodynamic assessment includes neurodynamic testing and nerve trunk palpation. Diabetes was shown to affect neural microcirculatory networks and neural connective tissue sheaths which may affect neurodynamic properties. The purpose of this study was to compare the neurodynamic findings in diabetic subjects, painless neuropathy and painful neuropathy with normal asymptomatic subjects., **Materials and methods:** The study was an observer-blinded cross-sectional study on 164 subjects (98 male, 66 female) of mean age ± years. Type-2 diabetes mellitus was diagnosed with fasting blood glucose levels and glycosylated haemoglobin. Peripheral neuropathy with VPT > 25 volts in bilateral feet; neuropathic pain identified on neuropathic pain questionnaire (NPQ) with NPQ score d" 0 implied painless and > 0 implied painful neuropathy. The tester administered neurodynamic testing and nerve trunk palpation to bilateral lower limb nerves. The outcomes of pain, resistance and range of motion for neurodynamic test and presence/ absence of mechanical allodynia on nerve trunk palpation were documented. Prevalence of neurodynamics among the study population was assessed for sciatic, tibial and common peroneal nerves., **Data analysis and results:** Prevalence data was analyzed descriptively using percentiles and compared using Chi-square test. One-way analysis of variance was used for comparing neurodynamic test findings across the nerve-groups at 95% confidence interval using SPSS 12.0.1 for Windows. Post-hoc analysis was done using Bonferonni test. Secondary analysis was done using paired t-test for to evaluate interaction of range of motion with study group. The PDPN group had the greatest abnormalities in neurodynamic examination findings compared to diabetic group. The painless neuropathy group was similar to normal group in their findings. Sciatic and tibial nerve was involved together in neurodynamic testing and all three nerves were sensitive to nerve trunk palpation in PDPN group., **Conclusion:** Abnormal neurodynamic findings in PDPN patients were demonstrated in terms of positive sciatic and tibial neurodynamic tests and by nerve trunk palpation for all three nerves. PDPN group had greater abnormalities in neurodynamics than diabetic subjects studied.

Key words: Neurodynamic testing, mechanosensitivity, diabetic neuropathy, manual therapy, nerve trunk palpation.

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INTRODUCTION

Neurodynamics is the concept based on a close interaction of mechanics and physiology of the nervous system which is to be considered while assessing and treating patients via nervous system mobilization and manual therapy.[1] This assessment and treatment approach allows us to physically

test the dynamics and the associated sensitivity of the nervous system.[2] The earliest understanding of this concept began with the term "neural stretching." However, the terms nerve-stretching,[3] adverse neural tension,[4] neural tissue provocation,[5] neural tissue extensibility,[6] neural mobilization[7] were suggested to be better replaced by the term "neurodynamics".[1]

Neural mechanosensitivity as a presenting clinical feature in many of the lower extremity musculoskeletal symptoms[8] was reported in the literature for plantar heel pain,[9] lumbar radiculopathy,[10] hamstring strain,[11] ankle sprain[12,13] and tarsal tunnel syndrome.[14] The physical signs of neural tissue involvement include adverse responses to neural tissue provocative testing and mechanical allodynia in response to palpation of nerve trunks.[15]

Neurodynamic tests involve thus a combination of selected joints' movements in a specific tested sequence that puts a dynamic load on the specific nerve trunk which may then elicit sensory or motor or autonomic responses.[16] Differentiation of neural and non-neural structures to be the source of elicited symptoms during the neurodynamic test is done using the process of structural differentiation- where when remote joint movements are added leading to alteration in elicited symptoms, it is expected to be of neural origin.[17]

Two types of neurodynamic dysfunction were identified to be slider and tensioner dysfunction[16] based on the underlying biomechanical basis of convergence and divergence in response to joint motion.[18] Successive addition of test components when increased the intensity of perceived symptoms is a characteristic of tensioner dysfunction where the symptoms are felt at end-of-range of the test. Mid-range symptom provocation and relief of symptoms with sensitizing maneuvers indicate slider dysfunction of the nerve.[16] Typically the nerve slider technique produces greater longitudinal excursion of the nerve along its bed compared to tensioner technique.[19]

Typically, a neurodynamic test assesses the neural mobility- intraneural and extraneural and its relationship to patient's symptoms. Extraneural mobility occurs between the nerve and its nerve bed or mechanical interface and intraneural mobility between the nerve fascicles and neural connective tissue sheaths. Neuromechanics and neurophysiology are two interdependent and inter-related phenomena where the neurodynamic environment is maintained by an adequate microneural circulation and neural metabolism.[7] The neuropathologic consequences on the neural mechanics, vascular perfusion, and axoplasmic flow must be considered when utilizing neurodynamic (gliding or tensioning) techniques for treatment.[20]

Whether these changes in peripheral nerves influence peripheral nerve neurodynamics and its relationship with patient's neuropathic symptoms is a point yet to be answered. Diabetes is well known to be the leading cause of symptomatic peripheral neuropathy and neuropathy is the most common and most disabling microvascular complication of diabetes.[21] Neural tissue mechanosensitivity was well demonstrated in experimental (animal) models of diabetic neuropathy.[22-25] Peripheral nervous system dysfunction clinically manifest as peripheral neuropathies in a large proportion of diabetic patients, presenting either as painful or painless neuropathies.[26] Peripheral neuropathic pain often presents as a combination of nerve trunk pain and dysesthetic pain.[27] Nerve trunk pain is typically described as a deep and aching sensation that has been attributed to increased activity from mechanically or chemically sensitized nociceptors in the connective tissue sheaths of the nervous system (i.e. nervi nervorum and sinuvertebral nerves).[28] Dysesthetic pain is often characterized as an unfamiliar or abnormal sensation such as burning, tingling, electric, searing, drawing, or crawling,[8] and it is thought to be the result of volleys of impulses originating from damaged or regenerating afferent fibers that have become hyperexcitable (i.e. abnormal impulse generating sites).[27] Nerve trunk pain typically presents as pain or abnormal sensations along the course of the peripheral nerve that can be clinically tested using the concept of neurodynamics.[29]

The aim of this study was to assess and compare the neurodynamic findings between normal subjects, type-2 diabetes subjects and patients with painless diabetic peripheral neuropathy and painful diabetic peripheral neuropathy.

MATERIALS AND METHODS

Study design

Cross-sectional study with assessor-blinding and random-order testing method.

Ethical clearance

The study's protocol was approved by Institution Ethics Committee of Kasturba Medical College (Manipal University), Mangalore, India and the trial was registered at Clinical Trials Registry- India under universal trial registration number UTRN 081455820-130920102690203.

Study location

Out-patient treatment unit of department of physiotherapy in a multi-specialty teaching hospital.

Participant selection

The four groups of participants were selected based on the following inclusion criteria;

Inclusion criteria

Normal subjects- Absence of present/ past symptoms in lower limbs, clear medical history, without family history of diabetes and/ or neuropathy.

Type-2 diabetes mellitus- Defect in insulin resistance or insulin secretion with serum glucose e" 200mg/dl 2h after 75-gm oral glucose load or Fasting Plasma Glucose (FPG) e" 126 mg/dl (7.0 mmol/l).

Peripheral neuropathy- Insensitivity to 5-gm Semmes-Weinstein Monofilament testing and vibration perception thresholds > 25 volts in bilateral feet.

Painless neuropathy- NPQ score d" 0.

Painful neuropathy- NPQ score > 0.

Participant recruitment

All participants were required to provide a written informed consent prior to their participation in the study. The consecutive participants were randomly assigned to receive either of two test procedures first. The allocation method was concealed from the primary investigator using sequentially numbered sealed opaque envelopes, generated by computerized table of random numbers method.

PROCEDURE- NEURODYNAMIC ASSESSMENT

Neurodynamic testing (NDT)[16]

Sciatic neurodynamic test- straight leg raise (SLR)$_1$

The examiner passively lifts the tested lower extremity with knee maintained in full extension till the onset of perceived symptoms or a feel of resistance. At that point, structural differentiation maneuver of ankle dorsiflexion or plantarflexion was done to observe for alteration in symptoms. A positive structural differentiation indicated altered neural mobility of the sciatic nerve. A normal response was a stretch or pull sensation felt behind the knee at maximum hip flexion which increased with ankle dorsiflexion and relieved with ankle plantarflexion.

Tibial neurodynamic test- SLR$_2$

The test is similar to the SLR_1 but the ankle dorsiflexion and eversion was performed before the SLR. The structural differentiation was done by hip adduction or internal rotation. A normal response was a stretch or pull sensation in the calf region.

Common peroneal neurodynamic test-SLR$_3$

The test is similar to SLR_1 and SLR_2, but the ankle movements of plantarflexion and inversion were performed before the SLR component. A normal response was a stretch or pull at the lower lateral part of the leg and dorsum of foot.

The neurodynamic test findings were recorded as positive or negative, depending

upon the reproduction of patient symptoms and alteration of symptom responses during structural differentiation. The amount of mobility was measured as range of motion of the neurodynamic test, using a standard universal goniometer with its stable arm along the lateral line of the body parallel to the plinth surface and its movable arm along the long axis of the thigh and fulcrum at greater trochanter.

NERVE TRUNK PALPATION (NTP)[30,31]

Sciatic nerve palpation

Sciatic nerve was palpated in the distal margin of the gluteal fold at or near the point between a line connecting greater trochanter and ischial tuberosity, where it exits from the greater sciatic notch.

Tibial nerve palpation

Tibial nerve was palpated in the medial aspect of the distal one-thirds of lower leg where it passes through the tarsal tunnel.

Common peroneal nerve palpation

Common peroneal nerve was palpated at near the fibular head (traced from posterior to anterior distal to the knee laterally) where it winds around the head and travels distally in the upper-third of the leg.

The nerve trunk palpation responses were recorded as positive or negative depending upon the mechanical allodynia provoked on manual palpation and reproduction of patient symptoms along the course of the nerve trunk. In case of normal response, a local tenderness may be occasionally felt.

The two outcome measures were recorded in random order, (selected by a toss of a coin method) by another physiotherapist who was blinded to study design. Total assessment duration per participant was for 30-min.

DATA ANALYSIS

Prevalence data of positive neurodynamic test, key signs on neurodynamic testing and nerve palpation test findings was analyzed descriptively using percentiles and compared using Chi-square test. One-way analysis of variance was used for comparing neurodynamic test findings of range of motion across the nerve-groups at 95% confidence interval using SPSS 12.0.1 for Windows. Post-hoc analysis was done using Bonferonni test.

RESULTS

Of the 388 participants who were contacted during the study period from November 2007 to October 2009, 290 volunteered to participate and were screened. The final included total number of participants was 164 with age 64.35 ± 7.11 years and either gender (117 male, 47 female). The overall participant characteristics are detailed in table-1. The participant characteristics and their comparisons on neurodynamic assessment findings for the four groups is shown in table-2.

NEURODYNAMIC TEST- FINDINGS

Right side lower limb

Positive neurodynamic test

There was a positive neurodynamic test finding in all the participants each of the four groups with a prevalence rate of 100%. The involvement of all three nerves was common in the normal, diabetic and painful neuropathy groups whereas the painless neuropathy group had greater prevalence of sciatic and common peroneal nerve involvement in combination. Chi-square test showed statistically significant (p=.022) differences between-groups (figure-1).

Key sign

Resistance was the key sign observed during the neurodynamic test in all three groups-normals, diabetics and painless neuropathy whereas muscle spasm and pain were most common in painful neuropathy group. Chi-square test showed statistically significant (p= .000) differences between-groups (figure-2).

Table 1: Overall characteristics of study participants in the four groups

Overall characteristics	Values
Sample size, N	164
Age (years)	64.35 ± 7.11
Gender- Male, female N (%)	117 (71.3%), 47 (28.7%)
Groups (Normals, diabetics, painless neuropathy, painful neuropathy), N (%)	38 (23.2%), 51 (31.1%), 30 (18.3%), 45 (27.4%)
Neurodynamic testing, (right side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal, N (%)	6 (3.7%), 20 (12.2%), 16 (9.8%), 36 (22%), 7 (4.3%), 22 (13.4%), 57 (34.8%)
Neurodynamic test findings (right side lower limb) Pain, resistance, muscle spasm, N(%)	39 (23.8%), 103 (62.8%), 22 (13.4%)
Neurodynamic test range of motion (right side lower limb) Degrees	63.41 ± 19.11
Neurodynamic testing, (left side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal, N (%)	10 (6.1%), 19 (11.6%), 16 (9.8%), 35 (21.3%), 9 (5.5%), 19 (11.6%), 56 (34.1%)
Neurodynamic test findings (left side lower limb) Pain, resistance, muscle spasm, N(%)	29 (17.7%), 113 (68.9%), 22 (13.4%)
Neurodynamic test range of motion (left side lower limb) Degrees	62.70 ± 20.9
Nerve trunk palpation (right side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal	2 (1.2%), 15 (9.1%), 21 (12.8%), 20 (12.2%), 13 (7.9%), 27 (16.5%), 66 (40.2%)
Nerve trunk palpation (left side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal	3 (1.8%), 9 (5.5%), 18 (11%), 28 (17.1%), 21 (12.8%), 21 (12.8%), 64 (39%)

N- Number of participants

All values in mean ± SD unless specified otherwise

Table 2: Group-wise characteristics of study participants in the four groups

Variables	Groups			
	Normals	Diabetics	Painless neuropathy	Painful neuropathy
Sample size, N*	38 (23.2%)	51 (31.1%)	30 (18.3%)	45 (27.4%)
Age (years)*	63.05 ± 6.23	64.27 ± 6.93	64.43 ± 7.15	65.48 ± 7.97
Gender- Male, female N**	24, 14	37, 14	24, 6	32, 13
Neurodynamic testing, (right side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal, N**	0, 4, 7, 7, 1, 6, 13	0, 8, 4, 9, 1, 6, 23	0, 4, 3, 10, 2, 6, 5	6, 4, 2, 10, 3, 4, 16
Neurodynamic test findings (right side lower limb) Pain, resistance, muscle spasm, N**	0, 38, 0	7, 44, 0	12, 18, 0	20, 3, 22
Neurodynamic test range of motion (right side lower limb) Degrees*	81.78 ± 4.8	74.72 ± 8.17	54.20 ± 3.51	41.22 ± 15.75
Neurodynamic testing, (left side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal, N**	3, 4, 6, 8, 1, 6, 10	0, 7, 5, 8, 1, 6, 24	1, 4, 4, 9, 2, 4, 6	6, 4, 1, 10, 5, 3, 16
Neurodynamic test findings (left side lower limb) Pain, resistance, muscle spasm, N**	0, 38, 0	4, 47, 0	3, 27, 0	22, 1, 22
Neurodynamic test range of motion (left side lower limb) Degrees*	83.26 ± 5.61	75.64 ± 8.74	56.66 ± 6.95	34.71 ± 9.4
Nerve trunk palpation (right side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal**	0, 3, 5, 6, 3, 7, 14	2, 6, 8, 6, 4, 10, 15	0, 5, 6, 4, 2, 5, 8	0, 1, 2, 4, 4, 5, 29
Nerve trunk palpation (left side lower limb) Sciatic, tibial, common peroneal, sciatic+tibial, sciatic+common peroneal, tibial+common peroneal, sciatic+tibial+common peroneal**	0, 2, 3, 3, 3, 9, 18	0, 3, 5, 5, 4, 11, 23	1, 4, 10, 7, 6, 1, 1	2, 0, 0, 13, 8, 0, 22

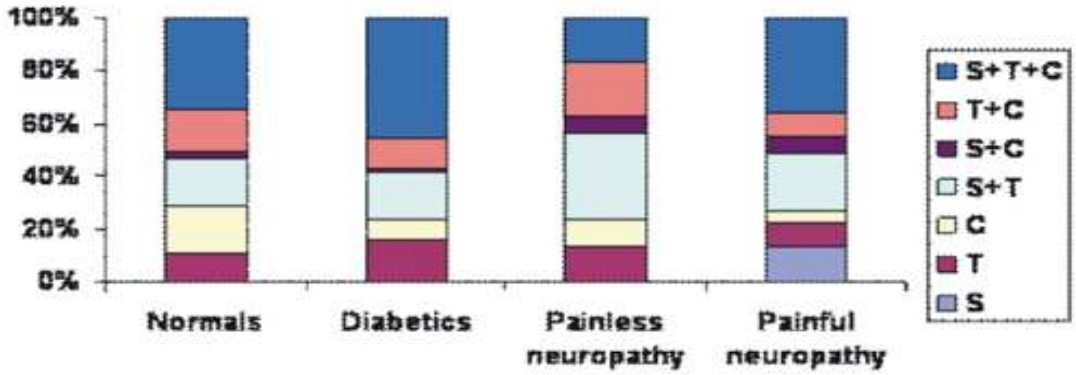
*Analyzed using one-way ANOVA; **Aanalyzed using Chi-square test

N- Number of participants; All values in mean ± SD unless specified otherwise

Range of motion

There was statistically significant differences in range of motion of positive-tested neurodynamic test between-groups in all the four groups. One-way ANOVA showed p=.000 and Bonferonni revealed all comparisons to be at p=.00. There was a significant reduction in range of motion as we compare across normals to diabetics, and then from diabetics to painless neuropathy and painful neuropathy groups with least neural mobility existent in painful neuropathy group (figure-3).

Figure 1: Between-group comparison of prevalence of positive neurodynamic test findings in nerves of right side tested lower limb (S- Sciatic; T- tibial; C- common peroneal; S+T- sciatic and tibial; S+C- sciatic and common peroneal; T+C- tibial and common peroneal; S+T+C- sciatic, tibial and common peroneal)



Left side lower limb

Positive neurodynamic test

There was a positive neurodynamic test finding in all the participants each of the four groups with a prevalence rate of 100%. The involvement of all three nerves was common in the normal, diabetic and painful neuropathy groups whereas the painless neuropathy group had greater prevalence of sciatic and tibial nerve involvement in combination. Chi-square test showed that the

Figure 2: Between-group comparison of prevalence of neurodynamic test findings of pain, resistance and muscle spasm in right side tested lower limb

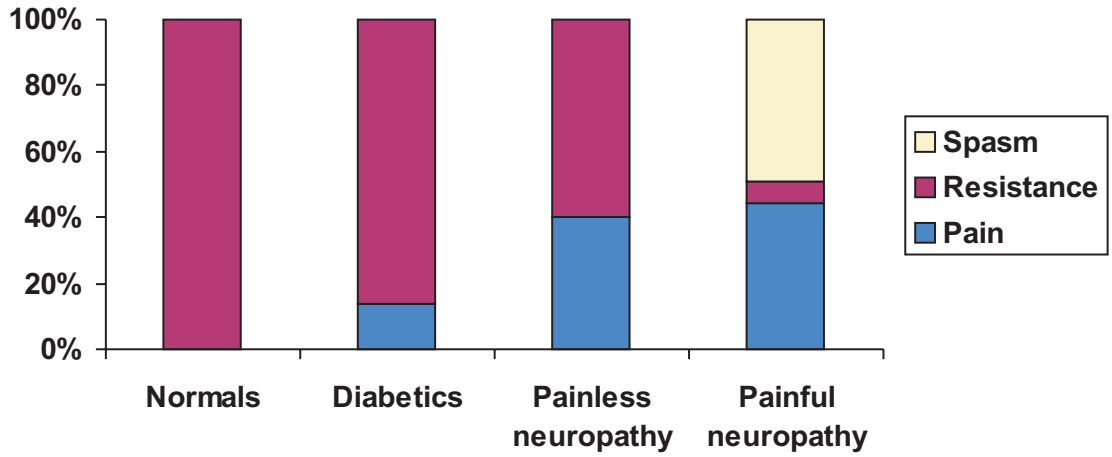


Figure 3: Between-group comparison of neurodynamic test range of motion (degrees) in right side tested lower limb

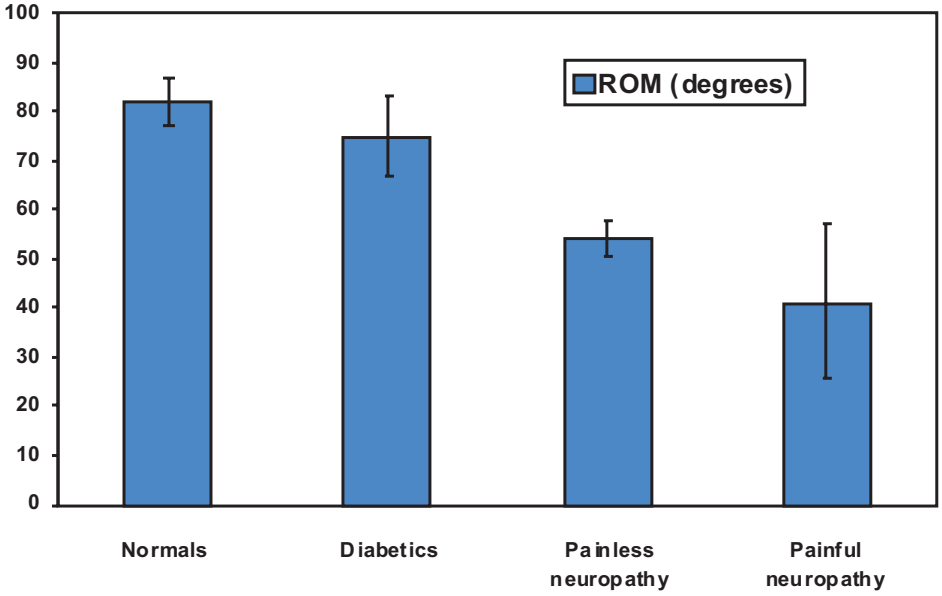


Figure 4: Between-group comparison of prevalence of positive neurodynamic test findings in nerves of left side tested lower limb (S- Sciatic; T- tibial; C- common peroneal; S+T- sciatic and tibial; S+C- sciatic and common peroneal; T+C- tibial and common peroneal; S+T+C- sciatic, tibial and common peroneal)

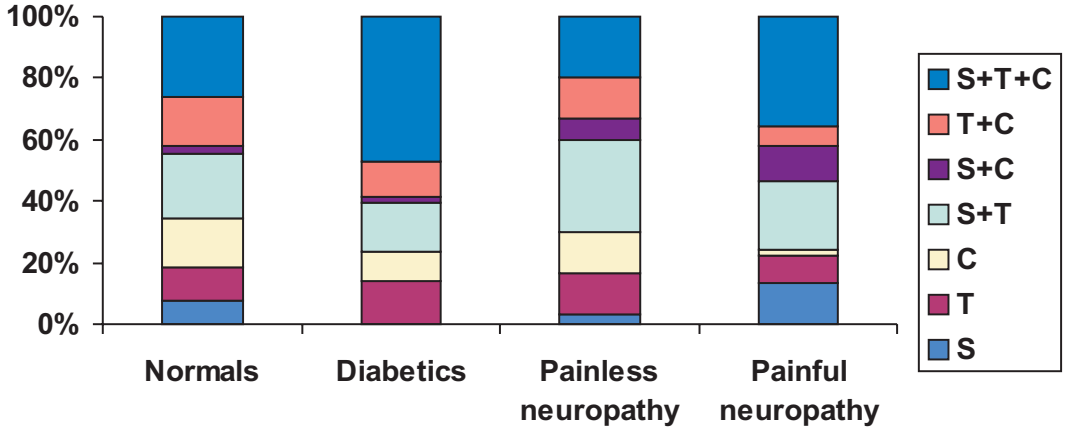


Figure 5: Between-group comparison of prevalence of neurodynamic test findings of pain, resistance and muscle spasm in left side tested lower limb.

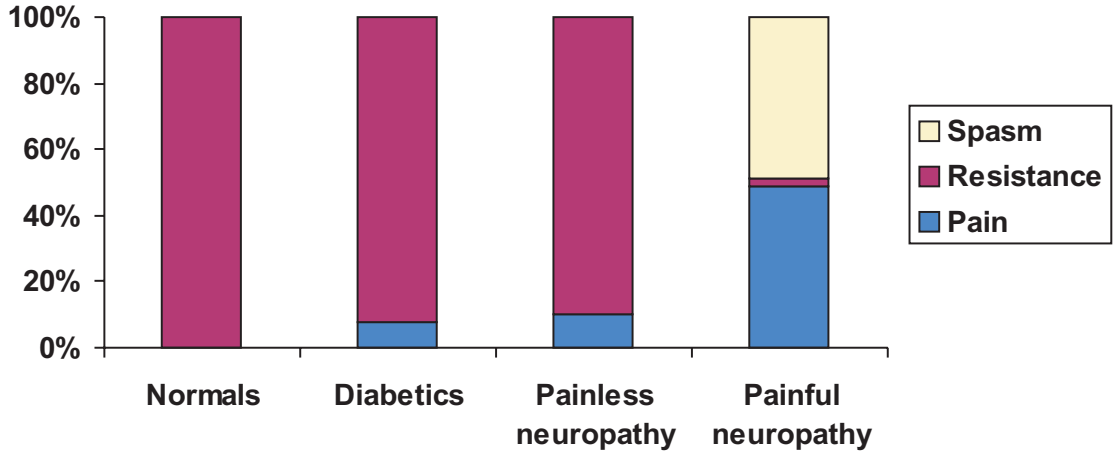


Figure 6: Between-group comparison of neurodynamic test range of motion (degrees) in left side tested lower limb

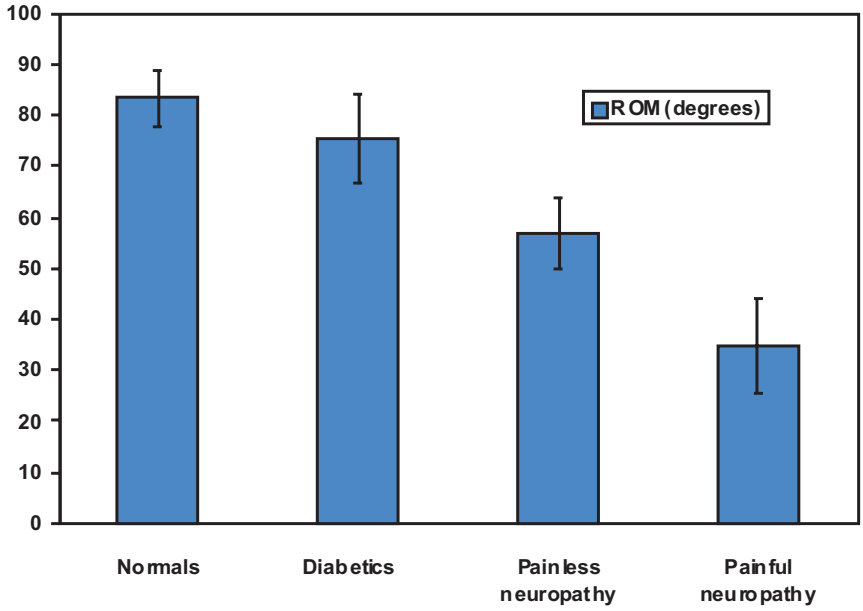
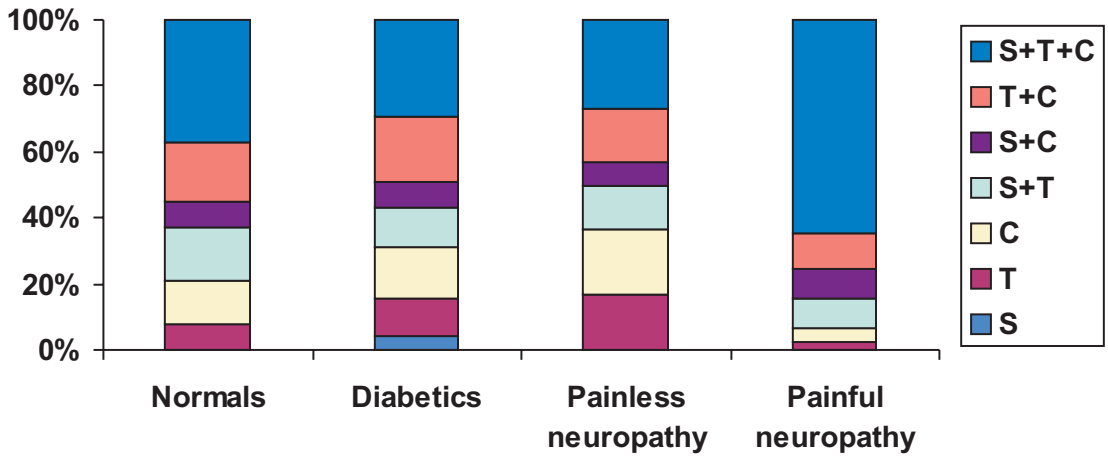


Figure 7: Between-group comparison of prevalence of positive nerve trunk palpation findings in nerves of right side tested lower limb (S- Sciatic; T- tibial; C- common peroneal; S+T- sciatic and tibial; S+C- sciatic and common peroneal; T+C- tibial and common peroneal; S+T+C- sciatic, tibial and common peroneal)

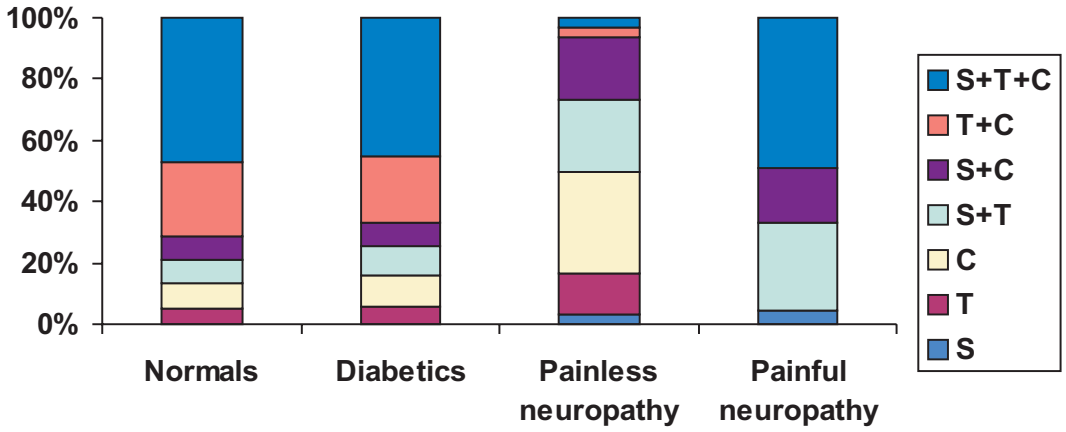


differences were not statistically significant (p=.115) between-groups (figure-4).

Key sign

Resistance was the key sign observed during the neurodynamic test in all three groups-normals, diabetics and painless neuropathy whereas muscle spasm and pain were most common in painful neuropathy group. Chi-square test showed statistically significant (p=.000) differences between-groups (figure-5).

Figure 8: Between-group comparison of prevalence of positive nerve trunk palpation findings in nerves of left side tested lower limb (S- Sciatic; T- tibial; C- common peroneal; S+T- sciatic and tibial; S+C- sciatic and common peroneal; T+C- tibial and common peroneal; S+T+C- sciatic, tibial and common peroneal)



Range of motion

There was statistically significant differences in range of motion of positive-tested neurodynamic test between-groups in all the four groups. One-way ANOVA showed p=.000 and Bonferonni revealed all comparisons to be at p=.00. There was a significant reduction in range of motion as we compare across normals to diabetics, and then from diabetics to painless neuropathy and painful neuropathy groups with least neural mobility existent in painful neuropathy group (figure-6). This trend was similar to that for the right lower limb.

Right lower limb

Mechanical allodynia to manual palpation was present in all three nerves in all the groups with an overall prevalence of 100%. Between-group comparison showed statistically significant difference between painful neuropathy versus the other three groups when analyzed using Chi-square test (p<.05). The painless neuropathy had the least number of nerves involved in combination, which was not statistically significant (p=.132).

Left lower limb

Mechanical allodynia to manual palpation was present in all three nerves in all the groups with an overall prevalence of 100%. Between-group comparison showed statistically significant difference between painful neuropathy versus the other three groups when analyzed using Chi-square test (p<.05). The painless neuropathy had the least number of nerves involved in combination, which was also statistically significant (p=.000).

DISCUSSION

The study found greatest abnormal findings of neurodynamic examination in the painful neuropathy group and this may be attributable to the following reasons;

Presence of stimulus-evoked pain among the patients with diabetic peripheral neuropathic pain (DPNP) such as nerve trunk pain is mechanically sensitive and hence the patient symptom reproduction would have occurred during neurodynamic testing and nerve trunk palpation.[32]

While the painful neuropathy group had pain and muscle spasm as key signs during neurodynamic testing, the other three groups had tissue resistance as a key finding. Tissue resistance could be due to neural stretch beyond anatomical limits of mobility without mechanical or physiological alterations.[33] This could have occurred in the normal, diabetic and painless neuropathy groups. The range of motion during the neurodynamic testing was much less in the painful neuropathy group

since the first stop is at the initial pain or provoked spasm which would be much earlier than tissue resistance felt in the other groups.[33-35]

Mechanical allodynia with referred pain was noted in the painful neuropathy group whereas local pain on deep pressure was observed in other three groups during nerve trunk palpation. Nervi nervorum is sensitive to mechanical pressure during inflammatory states of peripheral nerve trunks and this could have caused such a finding.[36]

Possible explanation why neurodynamic alterations occur in peripheral nerves could be understood best based upon the detailed description by Walsh[20] as follows;

The three factors contribute to the hyperirritability of the peripheral nervous system and its interfacing tissues. The vascular system may be compromised by external compression or by adverse tension. Adverse tension may be the result of adaptive shortening of the peripheral nerve from positioning or external scarring of the nerve. Compromise of nerve's vascularity can lead to the release of chemical mediators such as histamine or bradykinins, potentially creating a state of inflammation in or around the connective tissues of the nerve, increasing its level of irritability. Vascular changes may also lead to alterations in neurovascular dynamics and intraneural fibrosis. External compression can lead to a compromise in axoplasmic flow. This compromise reduces the transport of neural filaments, microtubules, and neurotransmitters along the axon to its terminal ending and the return of metabolic byproducts, potentially altering the nerve's physiology and function. As a result of this chemically mediated inflammatory process and/or the loss of intra- or extraneural gliding capabilities, mechanical irritability of the nerve will occur, resulting in repetitive forces across the fixed (adherent) nerve segment. This loss in neural motion tolerance in one segment requires force attenuation to be achieved over a shorter segment of the nerve, exposing it to further damage or injury.[37]

The final consequence of peripheral neuropathology is fibrosis. Occurring in two ways, intra and extraneural fibrosis removes the nerve's inherent ability to elongate or potentiate tension within the nerve fascicles and the gliding that occurs between the connective tissue layers of the nerve and its interfacing tissues. Intraneural fibrosis causes the loss of the tortuous course (undulations) of the nerve, resulting in the loss of internal glide and its unfolding capability. Extraneural fibrosis limits the nervous system's ability to move within its nerve bed or between the interfacing tissues, creating mechanical interference. In either scenario, the lack of nerve mobility results in increased stress or strain delivered to a shorter nerve segment as joint motion occurs. This fibrosis may ultimately lead to the onset of pain and adaptive shortening of the nervous system, altering joint movement and extremity function. With diabetes and/or neuropathy, there may be a progressive alteration in neuromechanics which is attributable to changes occurring in the connective tissue sheaths especially the intraneural and extraneural fibrosis which is accelerated with disease, disuse or deconditioning.[38]

The study had some important strengths;

Assessor-blinding and random order of test administration with concealed allocation enhanced the internal validity.

The study yielded valuable data that provided clinically relevant information on the comparison of normal and abnormal responses and their characteristics. The differences in neurodynamic findings could be only attributed to the between-group characteristics since they were homogenous in confounding variables such as age, gender and duration of symptoms if any.

The study findings also added evidence to neurodynamics[39] and its importance IN evaluation of neurodynamics in diabetic and diabetic neuropathy patient population.

The study had the following limitations;

It is a clinical trial and not a community-based or population-based study. A large

multicenter trial would have shown different findings.

The study only showed an association or comparison, establishing a cause-effect inter-relationship would not be warranted from these findings.

Mechanisms of peripheral neuropathic pain is not yet clear,[40,41] and it is beyond the cope of this study to classify the neuropathic pain symptoms which could facilitate appropriate musculoskeletal physiotherapy treatments.[42]

Future larger cohort studies and multicenter trials are indicated to answer these questions which when obtained would possibly explain the therapeutic rationale behind the neurodynamic mobilization techniques in painful diabetic peripheral patients. Other investigations such as electrophysiologic test measures[43] and longitudinal nerve motion[44] measurements using ultrasonography[45] would also add value to our observed findings.

CONCLUSION

The painful diabetic peripheral neuropathy group had statistically significant abnormal findings during neurodynamic testing and nerve trunk palpation compared to the other three groups studied.

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