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Relationship between Duration of Diagnosis and Neuromusculoskeletal Complications of Middle-Aged Type 2 Diabetes Patients

Rapport Entre Duree D'evolution Du Diabete Et Les Complications Neuromusculaire Chez Les Patients Diabetiques De Type 2 D'age Moyen

A. F. Adeniyi*†, A. O. Sanya†, A. A. Fasanmade‡, M. Borodo§, A. E Uloko§

ABSTRACT

BACKGROUND: **Patients with Type 2 Diabetes (T2D) often present with complications involving the neuromusculoskeletal system which creep in as the condition advances in years. Hence there is a need to further understand how the duration of diagnosis of diabetes (DD) relates to the neuromusculoskeletal complications in order to design timely preventive programmes.**

OBJECTIVE: **To investigate the relationship between the duration of diabetes and neuromusculoskeletal complications in type 2 diabetes.**

METHODS: **This was a cross-sectional survey involving 139 consenting T2D patients and 139 age and sex-matched non-diabetic individuals. The participants were assessed for the DD and selected neuromusculoskeletal complications including muscle weakness, ranges of motion (ROM), pain and foot ulceration.**

RESULTS: **The mean DD was 7.82 ± 2.41 years. There were significant differences (p < 0.01) between the clinical variables of both groups. In the diabetic participants, significant inverse relationships (P<0.05) were obtained between the DDD and each of muscle strength {elbow flexors (r = -0.57), knee extensors (r = -0.63), handgrip (r = –0.82)}; ROM {wrist extension (r = -0.64) and ankle planterflexion (r = -0.63)}. Significant and direct relationships were obtained between the DDD and each of pain (r = 0.62) and ulcerative grading (r = 0.81).**

CONCLUSIONS: **Type 2 Diabetes patients have poorer neuromusculoskeletal variables and longer duration of diabetes is associated with reduced muscle strength, diminished ROM, gradual ulceration of skin of the feet and higher level of foot pain. Immediate therapeutic exercises against these complications soon after diagnosis of diabetes may help to decelerate their progression. WAJM 2010; 29(6): 393–397.**

Keywords: **Pain, Range of Motion, Strength, Neuropathy.**

RÉSUMÉ

CONTEXTE: *Les patients atteints de diabète de type 2 (DT2) présentent souvent des complications touchant le système neuro-musculosquelettique. Il est nécessaire de mieux comprendre comment la durée d'évolution du diabète (DD) impacte sur les complications neuromusculosquelettiques afin de concevoir des programmes de prévention en temps opportun.*

OBJECTIF: *Etudier la relation entre la durée du diabète et les complications neuromusculosquelettiques chez les patients diabètiques de type 2.*

METHODES: *Il s'agissait d'une étude transversale incluant 139 patients consentants DT2 et 139 sujets non diabétiques appariés selon l'âge et de sexe. Les participants ont été évalués pour le DD et certaines complications neuromusculosquelettique notamment la faiblesse musculaire, l'amplitude de mouvement (ROM), la douleur et l'ulcération du pied.*

RÉSULTATS: *La durée moyenne d'évolution était de 7,82 ± 2,41 années. Il y avait des différences significatives (p <0,01) entre les variables cliniques des sujets d'étude et de contrôle. Chez les participants diabétiques, des relations significatives inverse (P <0,05) ont été obtenues entre le DD et chacune des forces musculaires {fléchisseurs du coude (r = -0,57), extenseurs du genou (r = -0,63), poignée (r = -0,82)} et ROM {extension du poignet (r = -0,64) flechisseur plantaire et de la cheville (r = -0,63)}. Des rapports directs et importants ont été obtenus entre le DD et la douleur (r = 0,62) ainsi que le grade des ulcérations du pieds (r = 0,81).*

CONCLUSIONS: *Les diabètiques de type 2 ont de moins bon paramètres neuromusculosquelettiques. La durée d'évolution du diabète est associée à la réduction de la force musculaire, à la diminution de l'amplitude du mouvement, aux ulcérations des pieds et à l'intensité plus grande des douleurs aux pieds. Des mesures thérapeutiques immédiates contre ces complications dès le diagnostic du diabète peut aider à ralentir leur progression.* ***WAJM 2010; 29(6): 393–397.***

Mots-clés: *douleur, Amplitude de mouvement, force musculaire, neuropathie.*

Departments of †Physiotherapy, College of Medicine, University of Ibadan, Ibadan, Nigeria ‡Medicine, University College Hospital, Ibadan, Nigeria §Medicine, Aminu Kano Teaching Hospital, Kano, Nigeria

****Correspondence:*** **Dr. A. F. Adeniyi,** Department of Physiotherapy, College of Medicine,University of Ibadan, Ibadan, Nigeria.
E-Mail: adeniyifatai@yahoo.co.uk fadeniyi@comui.edu.ng Tel:+23408057325888

Abbreviations: 1RM, One Repetition Maximum; **DD,** Diagnosis of Diabetes; **ROM,** Range of Joint Motion; **T2D,** Type 2 Diabetes; **VAS,** Visual Analogue Scale

INTRODUCTION

Peripheral sensory neuropathy is an important complication of diabetes and a major contributor to diabetic foot ulcers.[1] Long duration of diabetes is also associated with an increasing risk of developing painful diabetic peripheral neuropathy and this has a significant negative effect on quality of life.[2] Type 2 Diabetes (T2D) can also affect the musculoskeletal system in a number of ways. This manifests in various disorders such as frozen shoulder, limited joint mobility, carpal tunnel syndrome, osteoarthritis, neuropathic (Charcot's) joints and diabetic amyotrophy.[3–4]

The insidious onset and asymptomatic nature of type 2 diabetes results in many people remaining undiagnosed and at great risk of developing life-threatening complications.[5] Lifestyle and pharmacological interventions can reduce the incidence of diabetes and delay its progression.[5] However, Ruderman and Schneider[6] propose that preventive measures of exercise and diet in particular are most likely to be effective only when initiated early in young individuals, before the onset of irreversible vascular alterations, and when life-style changes may be more acceptable. According to them, early identification of such individuals may be possible based on family history, the presence of components of the hyperinsulinemia-insulin resistance syndrome, and/or central obesity. Because of the disabling complications usually posed by the delay in comprehensive therapeutic measures for T2D patients, this study investigated the relationship between the duration of diagnosis of diabetes (DDD) and selected neuromusculoskeletal complications of middle-aged T2D patients.

SUBJECTS, MATERIALS, AND METHODS

This research was a cross-sectional survey of middle-aged Type 2 Diabetes (T2D) patients. The participants for this study were 139 volunteers attending the Specialty (Diabetic) Clinic of the Aminu Kano Teaching Hospital, (AKTH), Kano, Nigeria. They were between the ages of 40 and 60 years, met the eligibility criteria, and accepted to participate in the study. The participants were the only T2D patients in the research centre who were willing to participate in the study, hence a total of 139 non-diabetic participants who were matched with the T2D participants for age and sex were subsequently recruited to serve as controls. The eligibility criteria for the T2D patients included knowledge of duration of diagnosis, consent to measurements and willingness to give informed consent. The non-diabetic participants were those with negative diabetes status following two separate fasting blood sugar tests. They were members of staff of the Bayero University and the Aminu Kano Teaching Hospital, Kano. Participants with uncontrolled hypertension and those being treated for cardiovascular disorders were excluded. Participants were recruited consecutively as they became available. Ethical approval was sought and obtained for this study from the Ethical Committee on Research of the AKTH, Kano.

Methods and Definition of Terms

Duration of Diagnosis: The duration of diagnosis of T2D was obtained verbally from the patients. This was further confirmed from documentations in their case files. The duration of diagnosis represented the first time the patient was informed of the disorder by a qualified health personnel following a sugar blood test.

Muscle Strength: Assessment of the muscle strength in both upper and lower limbs was done for both groups of participants. Selected muscle strength measurements were those of elbow flexors and extensors, handgrip, and knee flexors and extensors.[7] One-Repetition Maximum (1-RM) method of muscle strength assessment as described by Brzycki[8] was used to determine the strength of the elbow and knee flexors and extensors. A prediction formula for strength based on 1-RM given by Brzycki[8] was used:

$$\text{Predicted 1–RM} = \frac{(X_1 - X_2) \times (Y_1 - 1) + X_1}{(Y_2 - Y_1)}$$

Where X_1 = the heavier weight; X_2 = the lighter weight; Y_1 = the repetitions performed with the heavier weight and Y_2 = the repetitions performed with the lighter weight. The result of the stronger side of the body for each measurement was documented and eventually analysed in this study.

Handgrip Strength: The handgrip dynamometer was used to measure the handgrip strength of the participants in kilograms (kg). The participant while standing held the dynamometer in one hand in line with the forearm. Maximum grip strength was then determined without swinging the arm. The stronger grip of the two hands was recorded.[9]

Pain Level: The visual analogue scale was used to measure the pain of the participants in the feet. The scale was explained to the participant and was asked to note his/her present level of pain. Mark 0 stood for 'no pain at all' while 10 stood for the 'worse pain'. The higher pain from either of the feet was documented for analysis.[10]

Ranges of Motion: A goniometer was used to measure the active flexion and extension ROM of joints of the wrist and ankle. The higher range obtainable from joints of either side was recorded in degrees (^{0}).[11]

Ulcerative Foot Grading: This was assessed to determine the status of the feet in terms of dermatological breakdown or formation of ulcers. This was assessed based on six gradings according to Wagner[12]: Grade 0 – No ulcer but high risk foot; Grade 1 – Superficial ulcer, commonest site is first metatarsal head; Grade 2 – Deep ulcer, no bony involvement; Grade 3 – Abscess with bony involvement; Grade 4 – Localized gangrene e.g. toes and heel and Grade 5 – Gangrene of whole foot.

Statistical Analysis

The data obtained were analyzed using: *Descriptive statistics* of mean and standard deviations; *Inferential Statistics* of Independent t test to compare the clinical variables between T2D patients and non-diabetic participants; Pearson's moment correlation coefficient (r) was calculated to reveal the relationship between the duration of

diagnosis and the selected neuro-musculoskeletal complications. Co-efficient of determination (r^2) was further determined to estimate the percentage of variance that is shared between two variables. Significance level was set at $p \leq 5.0\%$

RESULTS

Distribution of participants and clinical Variables

Most of the T2D participants were males 94(67.6%), between the ages of 50 and 60 years, (Table I) with overall mean age of 49.7 ± 9.6 years. Because the non-diabetic controls were purposively recruited to match the age and gender of the T2D patients, they had similar characteristics with the T2D patients. The mean DDD was 7.8 ± 2.4 years. About two-thirds (66%) of the T2D participants had pain in their feet while only 13.7% of the non-diabetic controls had pain in the feet. The ulcerative foot grading also showed that about a quarter of the T2D participants had their feet integrity between level zero and one, which represents a point between high risks of ulceration to actual superficial ulceration around pressure points of the feet. Only nine (6.4%) of the non-diabetic participants had their maximum ulcerative feet grading at zero level which represents a no ulcer but high risk foot.

Table 1: Demographic and Clinical Variables of Study Subjects

Variable	Type 2 Diabetes Patients	Non-diabetic Controls
Age group (years) [N(%)]		
40-49	52 (37.41)	42 (37.41)
50-59	68 (48.92)	78 (48.92)
60-69	19 (13.67)	19 (13.67)
Sex [Number (%)]		
Males	94 (67.63)	94 (67.63)
Females	45 (32.37)	45 (32.37)
Foot pain [N(%)]	92 (66.18)	19 (13.67)
Ulcerative Foot Grading [N(%)]		
Grade 0	5 (3.6)	9 (6.5)
Grade 1	29 (20.86)	0.00
Grades 2-6	0.00	0.00
Mean Duration of diagnosis (years)	7.82 ± 2.41	–
Mean Fasting Blood Glucose (mmol/l)	9.15 ± 3.73	5.12 ± 1.75

Table 2: Comparison of Neuromusculoskeletal Variables Between Type 2 Diabetes Patients and Non-diabetic Controls

	Means ± SD			
Variable	**T2D patients**	**Non-diabetic**	**t**	**p value**
Pain (VAS) (n = 92)	6.13 ± 2.21	1.53 ± 0.63	19.19	0.0001
Strength (1RM) (Kg)				
Strength of elbow flexors	13.07 ± 3.15	19.72 ± 8.67	8.55	0.0001
Strength of elbow extensors	11.62 ± 3.22	15.62 ± 5.33	7.57	0.0001
Strength of Knee flexors	24.17 ± 3.55	28.99 ± 2.61	12.89	0.0001
Strength of knee extensors	27.65 ± 4.37	37. 84 ± 6.14	15.94	0.0001
Handgrip strength	24.55 ± 5.72	42. 32 ± 5.75	25.83	0.0001
Ranges of Motion (ROM) (^{0})				
Range of wrist flexion	78.89 ± 5.81	88. 24 ± 3.45	16.31	0.0001
Range of wrist extension	65.62 ± 4.76	74.62 ± 6.12	12.57	0.001
Range of planterflexion	36.35 ± 3.41	47. 52 ± 7.18	16.56	0.0001
Range of dorsiflexion	12.50 ± 2.56	18.94 ± 3.11	18.84	0.0001
Ulcerative foot grading (n = 34)	0.86 ± 0.35	0.00	14.32	0.0001

1RM, One Repetition Maximum; VAS, Visual Analogue Scale

Comparison of Clinical Variables between the T2D Patients and the Non-Diabetic Controls

The comparison of the VAS scores of pain in the feet between the diabetic and non-diabetic participants shows that the T2D patients had a significantly higher pain scores ($t = 19.19$, $p < 0.0001$) than the non-diabetic participants (Table 2). Generally, there was asymmetry in terms of muscle strength and ROM of the selected muscles and joints hence the highest reading of either side were pooled and used for the analysis. The T2D patients had significantly lower muscle strengths for both the elbow and knee flexors and extensors ($p < 0.0001$ for all) than the non-diabetic participants. The handgrip strengths were also significantly lower ($t = 25.83$, $p < 0.0001$) in the T2D patients. The ranges of motion of selected joints were also lower in the T2D patients than the non-diabetic participants and the difference was significant ($p < 0.001$) for all the joints that were assessed. Significant difference ($t = 14.32$, $p < 0.0001$) also existed between the highest grade level of ulceration (Grade 1) found in the T2D patients and the highest level (Grade 0) for the non-diabetic participants.

Relationship between the duration of diagnosis and clinical variables

The Pearson's correlation co-efficient (r) between the duration of diagnosis and the selected variables of neuromusculoskeletal complications for the T2D patients are presented in Table 3. The duration of diagnosis was significantly ($p < 0.05$) and inversely

Table 3: Relationship between Duration of Diagnosis and Selected Neuromusculoskeletal Variables in Type 2 Diabetes

Variables	r	r^2	P
DD Vs Pain	0.62	0.38	<0.05
DD Vs Strength of elbow flexors	–0.57	0.33	<0.05
DD Vs Strength of elbow extensors	–0.61	0.37	<0.05
DD Vs Strength of Knee flexors	–0.58	0.34	<0.05
DD Vs Strength of knee extensors	–0.63	0.40	<0.05
DD Vs Handgrip strength	–0.82	0.67	<0.05
DD Vs Range of wrist flexion	–0.64	0.41	<0.05
DD Vs Range of wrist extension	–0.57	0.33	<0.05
DD Vs Range of planterflexion	–0.63	0.40	<0.05
DD Vs Range of dorsiflexion	–0.55	0.30	<0.05
DD Vs Ulcerative foot grading	0.81	0.66	<0.05

DD, duration of diagnosis; **P,** level of significance; **r,** correlation coefficient; **r^2,** coefficient of determination; **Vs,** versus

related to all the variables except those of pain and Wagner's classification of ulceration. The coefficients of determination (r^2) for the relationships are also presented in Table 3. This reveals that about 30% and 66% of the changes in the range of dorsiflexion and foot ulceration respectively could be attributed to the duration of diagnosis of diabetes.

DISCUSSION

Our main findings were that most of the T2D patients had been diagnosed for close to a decade and they presented with poorer neuromusculoskeletal variables when compared with their age and sex matched non-diabetic counterparts. For instance, the highest grade level of ulceration was found in about one quarter of the T2D patients and this was at Grade 1 representing superficial ulcers on the pressure points of the feet, while the highest level for the non-diabetic participants was Grade 0 representing no ulcer but high risk and only in about one tenth of the participants. We also found that the duration of diagnosis was significantly associated with poorer status of the selected neuromusculoskeletal variables.

Earlier research findings also reported significantly poorer neuromusculoskeletal parameters in diabetic patients than the non-diabetic population. These neuromusculoskeletal complications include peripheral neuropathy;[2] frozen shoulder, limited joint mobility, carpal tunnel syndrome, osteoarthritis, neuropathic (Charcot's joints) and diabetic amyotrophy.[3–4] Diabetic peripheral sensory neuropathy is also described as an important complication of diabetes and a major contributor to diabetic foot ulcers.[5] This complex disorder affects different sets of lower-limb nerve fibers and leads to a variety of clinical manifestations including pain and paraesthesia, and unsteadiness in gait.[13] The musculoskeletal complications of diabeties are due to metabolic perturbations (including glycosylation of proteins, microvascular abnormalities with damage to blood vessels and nerves; and collagen accumulation in skin and periarticular structures) resulting in changes in the connective tissue.[3]

We found that longer duration of diagnosis of T2D was significantly linked with decline in muscle strength, diminished range of joint motion, gradual ulceration of the skin of the feet and higher levels of feet pain. The moderate to high correlation obtained between duration of diagnosis and each of the selected neuromusculoskeletal complication is clinically important because it provides evidence that T2D patients with longer duration of diagnosis would likely present with neuromusculoskeletal complications. The coefficients of determination obtained revealed that a fair amount of the selected neuromusculoskeletal complications which occurred over time could actually be attributable to the duration of diagnosis of the T2D. The rest could however be due to other likely confounders such as age, sex, body frame, glycaemic control, medications and existence of other co-morbidities.

Some of the complications observed in the T2D patients may also be due to the poor glycaemic control noticed in most of the patients. Deteriorating levels of glycaemic control and an increased duration of diabetes have been claimed to be associated with increasing likelihood of peripheral neuropathy in diabetic patients.[2] Lack of warning symptoms or cues to danger also exposes this large population of relatively asymptomatic patients to high risk of neuropathic foot ulceration.[13] It is also likely that some patients with undiagnosed diabetes had neuropathy, and there is some evidence that undetected diabetes is associated with at least some cases of neuropathy.[14] According to Koopman *et al*[15] neuropathic complications accrue in patients even before clinical diagnoses of diabetes are made. Based on this, the approach of detecting diabetes only when clinical signs and symptoms are apparent may be too late to prevent complications indicating the need for a review of monitoring strategy.[15] Musculoskeletal complications are commonly seen in patients with longstanding history of Type 1 diabetes, but they are also seen in patients with T2D.[3] People with diabetes also present more with hand deformities and other musculoskeletal problems than the non-diabetic population.[4,7] Smith et al[4] however point out that this tendency is associated with the duration of diabetes rather than age or sex.

Study Limitations

This study had a number of limitations. We could not carry out the study on the actual duration of onset of T2D in our participants as most of them were unaware of this. The most accurate information obtainable from the participants and their case files was the duration they were diagnosed of T2D by a qualified health personnel, which in most of them also implied the time they knew they had the disorder for the first time. The duration of diagnosis in this

study therefore did not represent the actual duration of onset of T2D. The duration of onset could actually be longer and by implication have more far-reaching effects on the selected neuromusculoskeletal complications than the duration of diagnosis that we documented. In addition, the Wagner's assessment of the foot was not a gold standard diagnostic tool for peripheral neuropathy but used only because of its physical display of neuropathic affectation of the foot. The relationship observed between the duration of diagnosis and the neuromusculoskeletal complications in this study is not necessarily causal as there may be other confounding variables such as drugs, self motivation and individual activities of daily living that may influence the presentations. We also acknowledge that T2D patients may have other co-morbidities which may imply that they will be on other drugs that may affect the clinical variables that were assessed. However the duration of diabetes may be contributory in view of the moderate to high relationships observed.

Conclusions

We have found that increasing duration of diagnosis of diabetes is associated with reduced muscle strength, reduced range of joint motion, increased foot pain and ulceration. As such, once diagnosis of diabetes is made, no matter how late, substantial effort must be channeled to prevent onset or further progression of any neuromusculoskeletal complications rather than focusing only on glycaemic control. This is because neuromusculoskeletal complications usually creep in and are frequently unrecognized in clinical practice. It will be more rewarding if all experts in the management of diabetes mellitus strive at screening early for neuromusculoskeletal complications of diabetes rather than leaving it for chance or until onset of full blown complications before interventions are proffered. This will help to reduce morbidity occasioned by delayed intervention. We recommend further studies to establish the role of duration of diagnosis on other complications of diabetes mellitus.

Conflict of Interest

We declare none.

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