Assessment of Limited Joint Mobility of the Hand in Black Africans with Diabetes Mellitus and in Non-diabetics

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ABSTRACT

Objective: *This study is designed to further characterize Limited Joint Mobility (LJM) of the hand using quantitative goniometric measurements among Black Africans with Type 2 diabetes mellitus and non-diabetes.*

Methods: *Seventy-six patients with Type 2 diabetes and 63 normal controls matched for age and gender were purposively selected. Visual clinical examination and quantitative goniometric assessment of patients with DM and non-DM controls were done. The LJM was graded using the criteria of Silverstein et al. Glycaemic control and proteinuria were also assessed.*

Results: *Prevalence of LJM among Type 2 DM patients was 26.3% compared with 4.8% in normal controls. Subjects with LJM within the control group were significantly older than those with LJM within the DM group (*$p < 0.05$*). Prayer sign was 11.8% in DM patients compared with 4.8% of control. The flattening sign demonstrated by the inability to flatten their hands on a flat surface was more in patients with DM (10.5%) compared with 4.8% in the control group. Stage II LJM with 18.4% prevalence was the commonest followed by Stage III (7.9%) among patients with DM. Poor glycaemic control was found in 85%, using fasting plasma glucose and 70%, using 2-hour postprandial blood glucose (2 hpp).*

Conclusion: *We conclude that Black Africans with Type 2 DM only have moderately severe cases of LJM.*

Evaluación de la Limitación de la Movilidad Articular de la Mano en Africanos Negros que Padecen de Diabetes Mellitus y en los no Diabéticos

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RESUMEN

Objetivo: *Este estudio fue diseñado para caracterizar más a fondo la limitación de la movilidad articular (LMA) de la mano, usando mediciones goniométricas entre africanos.*

Métodos: *Setenta y seis pacientes con diabetes mellitus tipo 2 y 63 controles normales pareados por edad y género fueron seleccionados para este propósito. Se realizó un examen clínico visual y una evaluación goniométrica cuantitativa de los pacientes con DM y controles no DM. La LMA fue graduada usando los criterios de Silverstein et al. También se evaluaron el control glicérico y la proteinuria.*

Resultados: *La prevalencia de LMA entre pacientes con DM tipo 2 fue de 26.3% comparada con 4.8% en los controles normales. Los sujetos con LMA en el grupo de control fueron significativamente mayores en edad que aquellos con LMA en el grupo con DM (*$p < 0.05$*). La signo de las manos en oración fue 11.8% en los pacientes con DM comparado con el 4.8% del control. El signo de aplanamiento demostrado por la incapacidad de los pacientes de poner sus manos totalmente planas sobre*

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una superficie, fue mayor en aquellos con DM (10.5%) en comparación con el 4.8% del grupo control. La LMA de la segunda etapa con una prevalencia de 18.4%, fue la más común seguida por la de etapa III (7.9%) entre pacientes con DM. Un control glicémico pobre fue hallado en 85%, usando glucosa plasmática en ayunas.

Conclusión: *Concluimos que los africanos negros con DM tipo 2 presentan sólo casos moderadamente severos de LMA.*

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INTRODUCTION

The complications of diabetes mellitus are many and varied. Complications such as nephropathy, retinopathy and neuropathy are well known. Specific efforts to treat complications of "diabetic foot" have been reported. Foot complications other than foot ulcers have been documented among Africans with Type 2 diabetes (1). Various complications of diabetes occur also in the upper extremity and particularly the hand, "the diabetic hand". They include not only more specific diabetic related conditions like limited joint mobility (LJM) but also conditions related to the non-diabetic hand, such as trigger finger, Dupuytren's contracture and peripheral nerve compression lesions (2). Limited Joint Mobility is also known as diabetic cheiroarthropathy or stiff hand syndrome. Limited joint mobility has been described in juvenile diabetic patients (3, 4). Similar abnormalities are also frequently seen in adult diabetics (5). Limited joint mobility is a painless and non-disabling complication of diabetes caused by thickening and stiffness of periarticular connective tissue. It involves mainly the small joints of the hand and is often neglected until hand deformity is severe enough to interfere with daily life (5). It tends to begin in the fifth digits and extends radially. The prevalence is between 30– 40% in Type 1 and Type 2 diabetics (4, 5).

Limited joint mobility has been recognized as the most common and earliest long-term complication of Type I DM and it also occurs in Type 2 DM (7–9). There is documented evidence on the relationship between LJM and microvascular complications, whereas the age, DM duration and glycaemic control play inconclusive roles (10, 11). There is also a 3-fold increased risk of microvascular complications. This could provide clues to earlier diagnosis of long-term complications in this group of patients (3, 11, 12).

No known strong relationship has been established between LJM and glycaemic control in diabetics (13). Various degrees of LJM were observed in about one-third of patients with diabetes in South Africa (14). The syndrome of LJM is a common but not widely recognized musculoskeletal complication of diabetes. Since some of the characteristics of diabetic foot disease have been documented in this environment (1), it is appropriate to evaluate the problem of diabetic hand syndrome in this suburban environment, in an attempt to characterize the relevance of LJM in prognosticating the severity of DM in Blacks. This study will further characterize this syndrome using visual examinations and quantitative goniometric measurements, and its relationship to proteinuria and glycaemic variables among African patients with Type 2 DM. The acquisition of data from apparently non-diabetics provides baseline normative values for comparison.

SUBJECTS AND METHODS

Study Centre

The study was carried out prospectively at the Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) Ile-Ife. The hospital is a referral centre for over 1 million people in the five contiguous states of Osun, Ondo, Oyo, Ogun and Lagos in Southwestern Nigeria. This study was approved by the hospital ethics committee. It was therefore performed in accordance with the ethical standards laid down in the Helsinki Declaration of 1975 and revised 2002. Informed consent was obtained from all patients. The sample size for the assessment of Limited Joint Mobility was determined using PEPI 2005 and the formula $n = Z^2 * p\ (1-p)/C^2$. Z is level of confidence interval at 95% and C, the maximum acceptable difference was 9%. The prevalence rate (p) of 20.3% was used (15). The sample size of 76 was arrived at.

Seventy-six patients with Type 2 DM and 63 normal controls (non-DM patients) matched for age and gender were purposively selected for this study. Limited Joint Mobility of the hand was studied by visual clinical examination for qualitative measurement of the prayer sign and flattening sign, and quantitative goniometric assessment in diabetic and non-diabetic controls without evidence of arthritis. All quantitative goniometric measurements were taken from a position of full extension to that of full flexion.

Sampling/patient selection: Type 2 DM patients were purposively selected in the diabetes outpatient clinic at OAUTHC and the controls were randomly recruited from the general non-diabetic population in the hospital.

Inclusion criteria: All Type 2 DM patients matched with normal controls (non-DM patients) for age and gender were selected for the study provided they did not have any obvious previous hand pathology.

Exclusion criteria: Type 2 DM patients and controls with the following hand pathologies were excluded from the study:

- Previous history of hand infection
- Previous history of hand trauma
- Previous history of burns
- Patients with rheumatoid arthritis

Procedure

The following parameters were assessed: age, gender, height (measured on wall mounted stadiometer), weight (measured on electronic scale), Body Mass Index (BMI), Fasting Plasma Glucose (FPG), 2-hour postprandial glucose, type of DM and the duration of DM. The presence of proteinuria was determined with Albustix® test on at least two clinic visits. Prayer sign and Flattening sign were also used for qualitative assessment.

Goniometric quantitative assessment

The range of movement for each of the joint was assessed using the conventional goniometer – with two arms – the fixed and the moveable. The axis was positioned laterally on the joint axis while the fixed arm was aligned to the proximal bone (proximal phalange for the interphalangeal joint and metacarpal for the metacarpophalangeal joint). For the wrist, the fixed arm of the goniometer was aligned parallel to the distal radius. For the elbow, the fixed arm was aligned to the humerus while the axis was on the elbow joint at the level of the lateral epicondyles. In each case, the moveable arm of the goniometer was aligned to the distal bone of the joint at the position of maximal extension. The angle of inclination was read in degrees using the zero method. The patient was then asked to bend the respective distal part as fully as possible. The final angle after movement was also read. The difference between the initial angle (maximal extension) and the final angle (after movement) is the range of movement (ROM).

The determination of normal range of motion for each joint was done using the 10^{th} centile of the control. Only one investigator performed all the goniometric assessments. Examination involved passive extension of the interphalangeal and metacarpophalangeal joints to at least 60°, thumb metacarpophalangeal joint to at least 45°, wrist joint to at least 40° and elbow joint to at least 125°.

Limited joint mobility was graded following the criteria of Silverstein *et al* (4):

- Stage I: No limitation and equivocal or unilateral findings
- Stage II: Involvement of one or two proximal interphalangeal joints, one large joint or only the metacarpophalangeal joints bilaterally
- Stage III: Involvement of three or more proximal interphalangeal joints or one finger joint and one large joint bilaterally
- Stage IV: Obvious hand deformity at rest or associated cervical spine involvement.

The prayer sign is described as the inability to fully flatten the two palms when opposed and clasped together. The flattening sign is described as the inability to fully flatten the palm on a flat surface.

Statistical analysis

The data of this study were analyzed using descriptive and inferential statistics on SPSS (statistical package for the social sciences) software, release 11.0 for Windows. Means and standard deviations were computed; student *t*-test and chi-square (X^2) were used as appropriate. Significant difference was implied when p is < 0.05.

RESULTS

A total of 139 persons participated in the study. They were made up of 76 Type 2 DM patients and 63 controls. Table 1 shows the demographic and clinical parameters of patients and controls. Among the patients with DM, 42 were males and 34 were females giving a ratio of 1.2:1 and the controls were 35 males and 28 females that is a ratio of 1.3:1. The mean (± SD) age of DM patients was 57.74 (± 9.78) years with a range of 31–88 years, while that of the control was mean ± SD 54.73 ± 9.99 years with a range of 33–88 years. There was no significant difference between the ages, genders, heights, weights and BMI of patients and controls

Table 1: Clinical charateristics of Type 2 DM patients (subjects) and controls

	Subjects (DM) n = 76		Control n = 63		Test of Significance		
	Mean ± SD or n (%)	Range	Mean ± SD or n (%)	Range	*t*-test or X^2	df	*p* value
Age (years)	57.74 ± 9.78	31–88	54.73 ± 9.99	40–71	1.783	137	.077
Sex (M/F)	42/34		35/28				
Duration of DM (years)	5.94 ± 7.29	.08–31					
Height (Metres)	1.65 ± 0.09	1.46–1.90	1.65 ± 0.09	1.42–1.87	- .242	137	.809
Weight (Kg)	71.41 ±13.25	42–118	73.14 ± 15.66	45–105	- .691	137	.491
BMI (Kg/m^2)	26.37 ± 4.85	15.6–44.4	27.08 ± 6.38	15.9–41.70	- .723	137	.471
Prayer sign	9 (11.8%)		3 (4.8%)		2.189	1	.139
Flattening right hand	8 (10.5%)		3 (4.8%)		1.571	1	.210
Flattening left hand	5 (6.6%)		4 (6.3%)		.003	1	.956
Hypertension	47 (61.8%)		19 (30.2%)		13.866	1	.000*
FP G (ml/L)	8.67 ± 2.67	4.65–17.50	4.91 ± 0.59	3.20–5.80	11.902	137	.000*
2 hpp (ml/L)	11.82 ± 5.41	5.60–38.10	6.25 ± 0.45	5.00–7.20	8.950	137	.000*
Proteinuria	31(40.8%)		3(4.8%)		24.198	1	.000*

* p value < 0.05, BMI = Body mass index; FPG = Fasting plasma glucose

($p > 0.05$). The mean (± SD) FPG for DM patients was 8.67 (± 2.67) mmol/L with a range of 4.65–17.50 mmol/L. The mean (± SD) 2 hpp was 11.82 (± 5.41) mmol/L with a range of 5.60 – 38.10 mmol/L.

Comparing subjects with LJM in both groups, there was a significant difference between their ages (Table 2). The mean (± SD) height (m) of patients with DM and LJM was 1.62 (± 0.09) whereas control was 1.64 ± 0.11. There was no significant difference (t = -.298; df = 21; $p = 0.789$). Likewise, the weight and BMI of patients with DM and controls were not statistically significant (Table 2). Among the patients with DM and LJM, the mean (± SD) FPG was 9.60 (± 2.93) mmol/L and the mean ± SD 2 hpp was 12.78 (± 3.91) mmol/L. It thus appears that the blood glucose level was higher in patients with DM and LJM compared with the whole DM population (Tables 1 and 2).

Using FPG 15/76 (19.7%), patients with DM had good glucose control, compared with 3/20 (15%) patients with LJM (Stages II and III), 61/76 (80.3%) patients with DM compared with 17/20 (85%) DM patients with LJM had poor glucose control. Using 2 hpp, good glycaemic control was observed in 14/76 (18.4%) patients with DM but no patients with DM and LJM had good control. Also poor glycaemic control was observed in 56/76 (73.7%) patients with DM and 14/20 (70%) patients with DM and LJM. This was statistically significant ($X^2 = 6.129$; df = 2; $p = 0.047$) [Table 3]. Using dipstick (Albustix®), proteinuria was demonstrated in 31 (40.8%) patients with DM compared to 3 (4.8%) in the controls. It was observed that 17(94.4%) patients with DM and LJM had proteinuria.

Table 4 shows the various stages of LJM. Limited joint mobility was present in 20 (26.3%) patients with DM compared with 3 (4.8%) controls, the difference between the two groups was of statistical importance ($X^2 = 12.146$; $p = 0.002$; df = 2). Limited joint mobility (Stages I – III) were observed in patients with DM. There was no Stage VI seen in both groups. Stage I LMJ (being no limitation) was seen in 56

Table 2: Clinical charateristics of patients (subjects) and controls with LJM

Variables	Subjects (DM)		Control		Test of Significance		
	Mean ± SD or n (%)	Range	Mean ± SD or n (%)	Range	*t*-test or X^2	df	*p* value
Age (years)	63.70 ± 8.92	50–88	71.33 ± 0.58	71–73	-3.777	21	.001*
Sex (M/F)	9/11		1/2				
Duration of DM (years)	10.91 ± 9.92	.17–31					
Height (Metres)	1.62 ± 0.09	1.46–1.80	1.64 ± 0.11	1.52–1.73	- .298	21	.789
Weight (Kg)	76.05 ± 14.18	80–118	68.00 ± 19.08	46–80	.702	21	.546
BMI (Kg/M^2)	28.97 ± 5.39	20.5–44.4	26.67 ± 7.07	19.9–34.0	.540	21	.636
Prayer sign	4 (80%)		1 (20%)		.273	1	.602
Flattening right hand	3 (75%)		1 (25%)		.610	1	.435
Flattening left hand	3 (100%)		0 (0%)		.518	1	.472
Hypertension	14 (93.3%)		1 (6.7%)		1.546	1	.214
FP G (ml/L)	9.60 ± 2.93	8.70–26.20	5.10 ± 0.40	6.30–6.90	6.482	21	.016*
2hpp (ml/L)	12.78 ± 3.91	5.10–17.45	6.53 ± 0.32	4.70–5.50	6.988	21	.000*
Proteinuria	17 (94.4%)		1 (5.6%)		4.093	1	.048*

* p value < 0.05

Table 3: Stages of limited joint mobility and plasma glucose control in DM patients

Stages	Fasting Plasma Glucose		Test of Significance	2hours post prandial		Test of Significance
	Good Control	Poor Control		Good Control	Poor Control	
I	12 (21.4%)	44 (78.6%)	$X^2 = .399$	14 (25%)	42 (75%)	$X^2 = 6.129$
II	2 (14.3%)	12 (85.7%)	df = 2	0 (0%)	14 (100%)	df = 2
III	1 (16.7%)	5 (83.3%)	$p = .819$	0 (0%)	0 (0%)	$p = 0.047$
IV	0 (0%)	0 (0%)		0 (0%)	0 (0%)	

Table 4: Analysis of various stages of limited joint mobility

Stages	DM n (%)	Control n (%)	Test of significance
I	56 (73.7%)	60 (95.2%)	$X^2 = 12.146$
II	14 (18.4%)	3 (4.8%)	df = 2
III	6 (7.9%)	0 (0%)	$p = 0.002$
IV	0 (0%)	0 (0%)	
TOTAL	**76 (100%)**	**63 (100%)**	

(73.7%) patients with DM compared with 60 (95.2%) controls. Stage II was seen in 14 (18.4%) patients with DM compared with 3 (4.8%) controls. Stage III was seen in only 6 (7.9%) patients with DM and no control had this stage.

Prayer sign was positive in 9 (11.8%) patients with DM compared with 3 (4.8%) controls ($X^2 = 2.189$; df = 1; $p = 0.139$). Flattening sign was positive on the right hand in 8 (10.5%) patients with DM compared with 3 (4.8%) controls ($X^2 = 1.571$; df = 1; $p = 0.210$). It was present on the left hand in 5 (6.6%) patients with DM compared with 4 (6.3%) controls ($X^2 = 0.003$; df = 1; $p = 0.956$). Comparing subjects and control with LJM, though prayer sign and flattening were more in DM patients with LJM than controls with LJM, this was not of statistical significance (Table 2). Most of the DM patients and controls were non-manual workers 62 (81.6%) and 55 (87.3%) respectively. There was no significant difference between patients with DM and controls with LJM in terms of occupation ($X^2 = 1.210$; df = 1; $p = 0.270$).

DISCUSSION

Limited Joint Mobility (LJM) occurs as a result of thickening and stiffening of the periarticular connective tissue (6). Blacks are also known to be at higher risk of developing hypertrophy and thickening of scars and keloidal scars (16, 17). There was no significant difference in the ages, BMI and genders between the patients with DM and the controls ($p > 0.05$). This indicates the homogeniety of the two groups with respect to the mentioned variables. Type 2 DM is the commoner type of diabetes in our environment accounting for over 90% of the DM population. This study was therefore based on this type of DM (18). This study found a prevalence of 26.3% LJM compared with 4.8% for normal controls matched for age and gender among Type 2 DM patients. This differs from the work by Fernando *et al* in Sri Lanka that showed a prevalence of 18.5% LJM among Type 2 DM patients (19). This difference could be due to ethnicity and genetic factors. The formation of keloid has a familial clustering, increased prevalence in certain ethnic groups and the high concordance in identical twins suggest a strong genetic predisposition to its formation (20). The prevalence from this study is similar to the work of Huddle *et al* that showed LJM in less than one-third of their study population (14); although, their study population was Black with Type 1 diabetes.

Thick, tight waxy skin that are features of LJM were found in patients in this study. This was demonstrated as the presence of prayer sign in 11.8% of patients with DM compared to 4.8% of control and the inability to flatten their hand on a flat surface (flattening sign) found to be more on the right hand of DM patients 10.5% compared with 4.8% in the control group. The importance of this finding in the dominant hand is not really known as the occupation of the patients or they being non-manual workers was not statistically significant.

Using the composite staging criteria previously described by Silverstein *et al* (4), Stage II, with 18.4% prevalence was the commonest followed by Stage III, with 7.9% prevalence among DM patients. In this study, no Stage IV was seen. This could imply that Black Africans with Type 2 DM, only have moderately severe cases of LJM as demonstrated in this study. The diabetic patients' hands were generally less flexible than non-diabetic controls using our assessment of LJM. This finding is in agreement and comparable with other studies in the literature (12, 21).

Non-enzymatic glycation of proteins is a post-translational process that occurs with ageing and is accelerated in diabetes mellitus patients. This is because of the occurrence of Amadori end-products particularly in the presence of persistent hyperglycaemia that occurs in poorly controlled diabetic patients. Patients with LJM that had poor glycaemic control was 17/20 (85%), using FPG and 14/20 (70%) using 2 hpp. Advanced glycation end-products (AGE) are known to be responsible for the cross link and stiffness in persons with diabetes (it starts with the formation of reversible Schiff base between an amino group of the collagen and glucose and this rapidly becomes a stable AGE in the presence of continuous elevation of blood glucose). In the present study, over 2/3 of patients with LJM had suboptimal glycaemic control. Glycated haemoglobin would have been a better diagnostic tool to use for blood glucose control. This facility was not available in the study setting/centre. However, the mean plasma glucose (FPG/2 hpp), that was used, over time, is comparable with glycated haemoglobin.

The occurrence of LJM indicated the presence of long-term complications (4, 5, 22) and this has also been associated with early microvascular complications such as retinopathy, nephropathy and neuropathy (23, 24). In the present study, 94.4% of DM patients with LJM had proteinuria (Dipstick positive on at least $\geq$ 2 clinic visits) [25]. The occurrence of proteinuria is consistent with a previous work done in this centre that show high prevalence of proteinuria in Type 2 DM (26).

This study has thus confirmed the involvement of LJM in Type 2 diabetes as seen in other works (8, 9, 19, 21). It also showed the association of LJM with poor glucose control and the presence of diabetic nephropathy (13, 25). Hence, the presence of LJM in clinical practice performed by passive manipulations can serve as an indicator of suboptimal glycaemic control and long-term complications like diabetic nephropathy in patients. Despite this observation, LJM should not be a substitute for other appropriate evaluation of other long-term complications of DM.

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