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NEUROMUSCULOSKELETAL DISORDERS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: OUTCOME OF A TWELVE-WEEK THERAPEUTIC EXERCISE PROGRAMME

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ABSTRACT

Background and Objectives: Usual line of management of diabetes patients is drug and diet with their physical needs usually receiving minimal attention. Among the physical needs, requiring attention is their neuromusculoskeletal disorders. This study was designed to investigate the effect of a twelve-week therapeutic exercise on neuromusculoskeletal disorders of Type 2 Diabetes (T2D) patients.

Methods: Forty-three participants from the Diabetes Specialty Clinic of Aminu Kano Teaching Hospital, Kano completed the study. Selected neuromusculoskeletal disorders including pain, dermatological foot grades, disorders of ranges of motion and strength of selected joints and muscles were assessed before and after a period of twelve weeks of therapeutic exercises. Participants were followed up for another twelve weeks without therapeutic exercises.

Results: Baseline assessment revealed poor neuromusculoskeletal status. Significant improvements ($P<0.05$) were obtained for pain, Severity of Dermatological Foot Grading, Muscle strength (One Repetition Maximum) and Range of Motions at the end of the exercises except that of right wrist extension ($P>0.05$).

Conclusions: T2D patients presented with neuromusculoskeletal disorders at baseline. Therapeutic exercises however assisted in the improvement of these disorders but relapsed when exercises were suspended. Engagement in therapeutic exercises enhanced neuromusculoskeletal health, while withdrawal from the exercise contributed to a decline. T2D patients should be encouraged to participate in therapeutic exercises in order to promote their health and function.

Keywords: Type 2 Diabetes, Strengthening Exercises, Foot Care Exercises. *(Accepted 14 December 2009)*

INTRODUCTION

Not long ago, diabetes mellitus was regarded as rare in Africa, but, it is now rightly regarded as a major health problem and a challenge throughout the continent[1]. According to Passmore and Eastwood[2], with urbanization and increasing prosperity, the prevalence of Type 2 diabetes (T2D) is rising but most of the cases occur in the middle-aged and the elderly. The inclusion of therapeutic exercises as an important part of the routine management of diabetes mellitus has not been receiving adequate clinical application[3-4]. In a study by Jorgensen et. al.[5], to determine which preventive methods is/are commonly recommended by health professionals, they reported that exercise schedules were the least commonly recommended of these four diet, exercise, weight control and education. However, a person with T2D may exhibit a range of multiple complications from insulin intolerance, depressed physical fitness, depressed pain tolerance, neuropathy, musculoskeletal manifestations, angiopathy to low quality of life[1, 6-7]. According to Piette and Kerr[8], as the proportion of diabetics with multi-morbidities continue to soar, essential research needs to be done on how to best organize care for diabetic patients with these conditions to maximize clinical outcomes and quality of life. This study adopted therapeutic exercises as one of the management protocol in the total management of diabetes and it was aimed at identifying the effects of these therapeutic exercises on the neuromusculoskeletal disorders of diabetic patients.

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MATERIALS AND METHODS

The participants for this study were Type 2 diabetes mellitus patients attending the Specialty (Diabetic) Clinic of the Aminu Kano Teaching Hospital, (AKTH), Kano. They were between the ages of 30 64 years, referred by their physicians and met the inclusion criteria. Forty three out of the 77 participants who enrolled originally completed the study. They were enrolled into the study as they became available. The study was prospective and included the pre-test, intervention and post-test

phases. The venue of this research was the gymnasium of Physiotherapy Clinic, AKTH, Kano.

Ethical approval was sought and obtained for this study from the Ethical Committee on Research of AKTH, Kano. There were two research phases that spanned 24 weeks namely: the Experimental Research Phase (ERP) i.e. with exercises of 12 weeks duration and the Follow-Up Phase (FUP) i.e. without exercises also spanning 12 weeks. Each participant went through these two research phases. Participants were allowed to continue their prescribed drugs and/or diet during the study period. Neuromusculoskeletal disorders studied were pain, dermatological foot disorders, ranges of motion disorders of selected joints and muscle weakness of selected muscles.

Data Collection: The following data from participants were recorded as baseline at their first appearance and also at the end of the 12th and 24th weeks in both the ERP and FUP of this study.

1) *Muscle Strength:* Assessment of the muscle strength of both upper and lower limbs was done using dumbbells and detachable weights of various sizes. Muscle strength measured were those of elbow flexors and extensors, hand grip and knee flexors and extensors[9]. One-Repetition Maximum (1-RM) method of muscle strength assessment as described by Brzycki[10] was used to determine the 1RM of the upper and lower limbs. A prediction formula for 1-RM given by Brzycki[10] is:

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

Where X_1 = the heavier weight

X_2 = the lighter weight

Y_1 = the repetitions performed with the heavier weight

Y_2 = the repetitions performed with the lighter weight

2) *Pain Level:* This was assessed using the visual analogue scale as described by Main and Spanswick[11].

3) *Handgrip Strength:* The handgrip dynamometer by Chang Inc. Hong Kong 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 better of two trials for each hand was recorded.

4) *Ranges of Motion:* A full circle goniometer made by Whitehall Incorporated, London, was used to measure the active ROM of joints of the shoulder, wrist and ankle joints[1]. This was recorded in degrees. The *joints of the fingers* were measured as described by Starkman, et. al.[12]: The participants were asked to make a prayer sign by placing both palms and fingers such that they fully opposed each other while the wrists were maximally extended. It was regarded as deformity if the palms and any of the fingers did not make good contact[12]. In the same prayer form, the number of fingers with deformity were noted and recorded[12].

5) *Dermatological Foot Grading:* This was assessed to determine the status of the foot in terms of dermatological breakdown. This was assessed based on five grades according to Birk and Sims[13]. These were:

Grade 1- Deep cracks and ulcers.
Grade 2- Deep cracks only.
Grade 3- Superficial cracks.
Grade 4- Heavy callus around pressure points.
Grade 5- Smooth skin.

Only grades 3 and 4 were included in this study.

The Therapeutic Exercise Regimen:

The total duration of exercise per session was between 50-60 minutes[14-15]. This included ten minutes of warm-up and cool-down exercises of five minutes each and about 40 to 50 minutes of main exercises. The exercise sessions were done three days per week with alternate days of rest. This made 36 sessions in the Experimental Research Phase. This was followed by a period of 12 weeks of follow-up without exercises (Follow up Phase).

1) Exercise regimen I (Endurance): The participants pedalled a bicycle Ergometer (by Bodyguard Inc. England) at an intensity of 60% of Heart Rate Reserve (HRR); i.e. [$0.6\ X\ (Heart\ Rate_{max}\ \ Heart\ Rate_{rest}) + Heart\ Rate_{rest}$] for about 20 minutes[14] with five minutes break in between[14-15].

2) Exercise Regimen II (Limb care): The participant immersed feet into a plastic water basin of about 25 inches wide and 20 inches deep with blunt edges, half filled with water at room temperature. The participant's limb stayed in the water basin for a period of five minutes to get soaked. The limb was brought out of the basin and the softened superficial layer of any rough callus was removed with the blunt edge of a stainless spoon to prevent cuts[16]. The limb was replaced into the water basin and participant was instructed to carryout free active movements of the ankle joint and toes in water for another five minutes. The limb was removed and suppleness was assisted by applying massaging olive oil over the skin to reduce evaporation and dehydration. Skin between the toes was dried to prevent maceration and reduce tinea infections[16].

3) Exercise Regimen III (Mobilization): Free active movements of the joints of the shoulder, elbow, wrists, fingers, hip, knees and ankle were carried out to as full range as possible[17]. Participants were encouraged by the researchers to mobilize the joints in the movement planes as full as possible making ten

repetitions in each.

4) Exercise Regimen IV (Strengthening):

- Strengthening exercises of the flexors and extensors of the knees and elbows[18] were carried out in this session. 60% of the individual's one repetition maximum (60% of 1RM) was determined and used to strengthen each group of muscles. Participants were asked to perform two sets of ten repetitions each with recovery time of two minutes between sets[18]. New 1RM were determined fortnightly in order to ensure progression of exercises.
- The participants also carried out strengthening exercises for both hands using the Lawn tennis balls. They were encouraged to squeeze the balls as strongly as they could, making ten repetitions each.

Analysis of Data

The data obtained were analyzed using: Descriptive statistics of mean and standard deviation; and inferential Statistics of repeated measures Analysis of Variance (ANOVA) and Scheffe's post hoc analysis. Significance level was set at 0.05 level of alpha.

RESULTS

The mean age of the participants was 47.9 ± 9.93 years, made up of 15 males and 28 females. Table 1 shows the baseline levels of selected indices of neuromusculoskeletal disorder assessed for the participants. The mean level of pain felt by the participants at the beginning of the study was 5.42 ± 1.22 (n = 14) while the mean number of their fingers with range deformities (NFD) was 1.75 ± 0.62 (n = 12). The mean Severity of Dermatological Foot Grading (SDFG) on a 5-point scale of increasing severity from 5 to 1 was 4.16 ± 0.81. Mean Right Handgrip Strength (RHGS) at baseline (25.97 ± 7.82 kg) was higher than the Left Handgrip Strength at baseline (22.02 ± 6.90 kg). Muscle strength of other selected muscles using the One Repetition Maximum (1RM) is also shown in Table 1. Table 1 also contains the descriptive statistics of the Ranges of Motion (ROM) of selected movements at baseline. The mean ROM of Left Shoulder Flexion (RLSF) was 160.58 ± 11.97^0 while that of the Right Ankle Flexors (RRAF) was 13.09 ± 3.19^0. Significant differences ($P < 0.05$ for all) were obtained when these variables were compared with those of matched, apparently normal non-diabetic individuals.

Table 1**: Descriptive statistics of variables assessed for neuromusculoskeletal disorders of participants at baseline.**

Variable	Mean ± SD	95%CI
Pain (n = 14)		
Visual Analogue Scale (VAS)	5.42 ± 1.22	4.72-6.13
ROM Deformity in Fingers (n = 12)		
Number of Finger Deformity (NFD)	1.75 ± 0.62	1.35-2.14
Severity of Dermatological Foot Grading (DFG)		
Left	4.16 ± 0.81	3.91-4.41
Right	4.16 ± 0.81	3.91-4.41
Muscle Strength (1RM) (Kg)		
Left Elbow Flexors	12.18 ± 3.36	11.07-13.30
Right Elbow Flexors	14.04 ± 3.19	13.06-15.02
Left Elbow Extensors	9.86 ± 2.19	9.18-10.53
Right Elbow Extensors	12.65 ± 3.19	11.66-13.63
Left Knee Flexors	23.90 ± 4.55	22.50-25.30
Right Knee Flexors	23.02 ± 4.41	21.66-24.38
Left Knee Extensors	26.65 ± 5.10	25.08-28.22
Right Knee Extensors	24.93 ± 3.98	23.70-26.16
Left Handgrip	22.02 ± 6.90	19.89-24.15
Right Handgrip	25.97 ± 7.82	23.56-28.38
Range of Motion ROM (^{0})		
Left Shoulder Flexion	160.58 ± 11.97	156.89-164.26
Right Shoulder Flexion	160.51 ± 15.20	155.83-165.19
Left Shoulder Extension	41.41 ± 7.18	34.20-43.62
Right Shoulder Extension	40.65 ± 6.99	38.49-42.80
Left Wrist Flexion	79.06 ± 6.92	76.93-81.20
Right Wrist Flexion	80.18 ± 6.47	78.19-82.17
Left Wrist Extension	66.04 ± 6.32	64.10-67.99
Right Wrist Extension	70.93 ± 4.11	69.66-72.19
Left Ankle Flexion	11.60 ± 2.42	10.85-12.34
Right Ankle Flexion	13.09 ± 3.19	12.10-14.07
Left Ankle Extension	38.48 ± 4.43	37.12-39.85
Right Ankle Extension	39.20 ± 5.34	37.56-40.85

Table 2: **Variables showing significant changes (P < 0.05) at various stages of the study as shown by Scheffe's Post hoc analysis of the significant assessment periods.**

Baseline-12th **(Significant Improvement)** (P < 0.05)	12th-24th Wk **(Significant Decline)** (P < 0.05)	Baseline-24th Wk **(Improvement Sustained)** (P < 0.05)
Pain		
VAS	VAS	-
ROM deformities in fingers		
NFD	-	NFD
Severity of Dermatological Foot Grading (DFG)		
Left	Left	-
Right	Right	-
Muscle Strength (1RM) (Kg)		
Left Elbow Flexors	-	Left Elbow Flexors
Right Elbow Flexors	Right Elbow Flexors	-
Left Elbow Extensors	Left Elbow Extensors	-
Right Elbow Extensors	-	Right Elbow Extensors
Left Knee Flexors	-	Left Knee Flexors
Right Knee Flexors	Right Knee Flexors	-
Left Knee Extensors	Left Knee Extensors	-
Right Knee Extensors	Right Knee Extensors	-
Left Handgrip	Left Handgrip	-
Right Handgrip	-	Right Handgrip
Range of Motion ROM (^{0})		
Left Shoulder Flexion	Left Shoulder Flexion	-
Right Shoulder Flexion	Right Shoulder Flexion	-
Left Shoulder Extension	-	Left Shoulder Extension
Right Shoulder Extension	-	Right Shoulder Extension
Left Wrist Flexion	-	Left Wrist Flexion
Right Wrist Flexion	-	Right Wrist Flexion
Left Wrist Extension	-	Left Wrist Extension
Left Ankle Flexion	Left Ankle Flexion	-
Right Ankle Flexion	-	Right Ankle Flexion
Left Ankle Extension	-	Left Ankle Extension
Right Ankle Extension	-	Right Ankle Extension

The comparison of the neuromusculoskeletal variables (Repeated measures ANOVA table not shown) including strength, pain, finger deformities, foot grading and ROM reveals significant differences across the assessment periods i.e. baseline, 12th and 24th weeks (P < 0.05 for all variables except range of right wrist extension where P>0.05). Schaffe's post hoc further revealed the changes that were significant at each of the assessment periods (Table 2).

DISCUSSION

The neuromusculoskeletal parameters studied included pain, presence of Range of Motion (ROM) deformities in fingers and other selected joints, signs of diabetes foot neuropathy and muscle strength. About one third of the participants had pain of musculoskeletal origin. This was pain within the range of motions of shoulders, fingers and ankle joints. Earlier, Sanya et. al.[9] and Smith et. al.[19] in their reports documented that people with diabetes usually present more with hand deformities and other musculoskeletal problems than the non-diabetic population and this leads to pain. The pain levels of the participants in this study however reduced significantly by the twelfth week of the therapeutic exercise (table 2). About a third of the participants' had difficulties making a full "prayer sign" with their two hands because of disorders in ROM of their fingers. Persons with diabetes usually have this disorder due to pronounced thickening of periarticular collagen following non-enzymatic glycosylation of collagen[19]. The participants with ROM problems in their fingers showed improvement by the twelfth week because the number of fingers impeding this function reduced to about one. The ROM of other selected joints also showed improvement after the twelfth week of the therapeutic exercise programme (table 2). Studies

had earlier suggested that regular joint mobilization exercises should be included in the treatment regime of the diabetic patient, irrespective of whether joint limitation is the presenting complaint or not[19].

The Dermatological Foot Grading (DFG), as described by Birk and Sims[13] revealed a mean level that was near normal at baseline in the participants. This could however be because the study excluded those with advanced diabetes foot neuropathy. However, the mean baseline level of DFG revealed the need for more proper foot care in this group of patients since some of them presented with some level of dermatological affectation. The DFG improved significantly by the twelfth week. The rough sole of the feet in most of the participants transformed to a smoother and subtler sole by the end of the exercise phase. Warren[16] reported that immersion of feet in water helps to maintain subtleness of the feet. This present study further observed that immersion and exercises of the feet in water for about fifteen minutes, three times weekly would help to add to the smoothness of the feet and increase ROM of the ankles.

The effect of therapeutic exercises on the muscle strength of persons with Type 2 diabetes mellitus is revealed with the significant improvement in One Repetition Maximum (1RM) of the participants. This increase in strength was noticed in all the selected muscles studied (Table 2). Brandon et. al.[18] had reported similar improvements in their study when muscle strength of the trained plantar flexors, knee extensors, knee flexors, hip extensors, and hip flexors groups were trained at 50%, 60%, and 70% of 1-repetition maximum. In an evidence based review carried out on a number of studies, White et. al.[20] also stated that there is evidence that progressive strengthening exercise programmes were moderately effective in increasing the strength of tested muscles.

The achievements derived from the therapeutic exercise phase began to decline when the therapeutic exercises were suspended (Table 2). Strength of most muscles depreciated by the 24th week. Some ROM were compromised, especially by pain, which also increased concurrently. The constant dryness and coarseness of the feet also reappeared at the follow up phase. The prayer sign test as a pointer to finger deformities also became more impaired though they could do it better than what was experienced in the baseline.

CONCLUSION

In conclusion, persons with Type 2 diabetes mellitus did have impaired neuromusculoskeletal disorders. The disorders however improved following a period of twelve weeks of therapeutic exercise intervention in addition to their drugs and/or diet.

The improvements achieved were fairly stable at the early part of the follow-up phase only to decline by the end of twelve weeks without therapeutic exercises. This implied that therapeutic exercises have beneficial effects on neuromusculoskeletal disorders of this group of patients and withdrawal from such exercises will bring about relapse in achieved benefits. It is recommended that persons with Type 2 diabetes mellitus should maximize the benefit of therapeutic exercises in order to improve functions and prevent deformities. Physicians and caregivers of patients with diabetes mellitus should also pursue this policy for the benefit of their patients.

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