DOI: 10.7860/JCDR/2023/62407.18027

Original Article

Physiology Section

Efficiency of Bimanual Hand Coordination among Type 2 Diabetes Mellitus Adults: A Case-control Study

TAITIKSH JAKHAR[1], ASHWINI K SHETTY[2], JAGADAMBA ASWATHAPPA[3], SV SRINIVASA[4]

ABSTRACT

Introduction: Distal Peripheral Neuropathy (DPN), which first affects the lower limbs and then the upper limbs, is one of the common complications of Type 2 Diabetes Mellitus (T2DM). In addition to DPN, diabetic patients have lower muscle quality than non diabetic patients, which is exacerbated by longer duration of diabetes and poor glycaemic control. Diabetic induced peripheral neuropathy and changes in the muscle strength may interfere with bimanual coordination, which refers to a wide range of situations in which the brain must control multiple movements at the same time such as performing a task with two hands.

Aim: To assess and compare Efficiency Index (EI) of bimanual coordination in T2DM and controls.

Materials and Methods: This case-control study was conducted conducted in the Department of Physiology at Shri RL Jalapa Hospital, Kolar, Karnataka, India, from August 2019 to September 2019. The study included 50 participants, 25 with T2DM and 25 age-matched controls. The bimanual hand coordination test apparatus was used to assess the efficiency of bimanual hand coordination. The data obtained was analysed using Statistical Package for Social Sciences (SPSS) version 20.0.

Results: The mean age of the study participants was 57.16±9.54 years and controls was 54.15±5.52 years and were age-matched with p-value >0.426. Mean HbA1c of the cases was 8.36±1.88 mmol/mol. There was significant decrease in efficiency of bimanual coordination among type 2 diabetics as compared to non diabetics (p-value <0.001).

Conclusion: The findings of the present study showed a decrease in bimanual coordination efficiency among diabetics, indicating the importance of performing hand function tests in T2DM alongside other routine examinations.

Keywords: Distal peripheral neuropathy, Efficiency index, Hand function

INTRODUCTION

Diabetes Mellitus (DM) is a most common chronic metabolic disorder across the world, that causes increase in blood glucose levels. In India, the prevalence of DM and Impaired Fasting blood Glucose (IFG) was 9.3% and 24.5%, respectively in the year 2017-18 [1]. DPN ranks as the most frequent complication among DM patients, with a prevalence in India ranging from 18.8 to 61.9% [2]. This complication affects 30-50% of patients with DM [3]. Diabetic neuropathy is a symmetric predominantly sensory neuropathy that affects lower limbs and later affects the upper limbs. Evidences suggest that, peripheral neuropathy in DM mostly effects the lower limbs [4,5] but studies have also highlighted the effects of DM on upper limbs [3,6]. In clinical practice, DPN in DM is diagnosed by signs and symptoms such as, numbness or reduced ability to feel pain or temperature changes, tingling sensation. Sharp pains or cramps in the limbs, muscle weakness, extreme sensitivity to touch, foot problems such as ulcers, infections, bone and joint damage [7]. Subclinical neuropathy affects 58-82% and 37-69% of diabetic patients, respectively, on their median and ulnar nerves [8,9]. Musculoskeletal complications are the most common long-term complication of diabetes which declines the muscular function [10]. These changes induced by DM might interfere with regular coordinating movements of both hands like the bimanual hand coordination. Bimanual coordination encompasses an array of situations in which the brain must control multiple movements all at the same, for instance when the authors used two hands to try and control an object or carry out an action. In order to carry out the daily activities, movements of both hands must be finely coordinated [11].

The central and peripheral nervous systems' integrity is critical for bimanual coordination [12-15]. Diabetic-induced peripheral neuropathy and changes in muscle strength may hinder diabetics' ability to perform bimanual coordination. Diabetes complications on bimanual hand coordination function have received far less attention. The purpose of the present study was to assess the efficiency of bimanual hand coordination in DM patient population and to compare the efficiency with age-matched controls. The present study may aid in improving patient care, freedom in daily living activities, and general well-being.

MATERIALS AND METHODS

This case-control study was conducted in the Department of Physiology at Shri RL Jalapa Hospital, Kolar, Karnataka, India. The duration of the study was two months, from August 2019 to September 2019. The study was chosen for a short-term studentship project sponsored by the Indian Council of Medical Research (ICMR) in 2019. The Institutional Ethics Committee approved the study (Document No. SDUMC/KLR/IEC/24/2019-20).

For the present study, a convenient sample 25 people with T2DM who went to the Department of Medicine for regular check-ups and diabetes treatment were recruited. A similar number of age-matched controls with no history of DM were recruited from the hospital's patient attendants or administrative staff. A written informed consent was obtained from all the subjects recruited for the study.

Inclusion criteria:

For cases:

- Subjects more than 30 years of age of both genders.
- Diagnosed with Type 2 Diabetes Mellitus (T2DM) [16]
- On treatment for DM more than five years.

For controls:

- Subjects more than 30 years age of both genders.
- Never diagnosed with type 1 and 2 DM.

Exclusion criteria: For both cases and controls:

- History of motor, behavioural, orthopaedic, learning or neurologic deficits.
- Subjects with history of primary uncorrected visual defect.
- History of alcohol abuse and vitamin deficiencies.

Study Procedure

On the same day of the experiment, each diabetic participant's glycated haemoglobin (HbA1c), fasting blood glucose, and postprandial blood glucose levels were tested. The healthy individuals recruited for the study had their blood sugar tested on the spot and found to be less than 140 mg/dL. To assess bimanual coordination: Bimanual hand coordination test apparatus [Table/Fig-1] with electric chronoscope (calibrated and validated by Anand agencies, Pune) was used to assess bimanual coordination in T2DM patients and controls.

[Table/Fig-1]: Bimanual hand coordination test apparatus with electronic chronoscope.

All subjects had to trace the figure on the apparatus from start to finish using two handles with both hands at the same time using the pointer, whereas, if the pointer touches the walls of the figure on the apparatus, an error (e) is committed and the chronoscope digitally records it in seconds. They were given three trials, each with a five-minute break in between. They were given ten minutes to rest before beginning the task at hand. The total time required to complete the test (T) and the error (e) committed during task completion were both recorded in seconds. The EI was computed as E.I=(T-e)/T *100 in both diabetics and non diabetics [17].

STATISTICAL ANALYSIS

The data obtained was analysed using SPSS software version 20.0. Mean±SD was used for data with normal distribution. The Mann-Whitney test was used to compare the EI among case and control groups. The p-value <0.05 was considered statistically significant.

RESULTS

The study included 50 participants, 25 who had T2DM and 25 of whom did not. A total 12 (24%) were females and 38 (76%) were males. Diabetics had a mean age of 57.16±9.54 years, while non diabetics had a mean age of 54.15±5.5 years. Both groups were age-matched (p-value=0.426). The baseline characteristics of both, study and control groups are given in [Table/Fig-2]. The normality was checked using Shapiro-Wilk test, which showed that EI was not normally distributed (W=0.642, p-value <0.001). Mann-Whitney U test indicated that, EI of bimanual hand coordination was significantly decreased in DM (median- 94.46: Confidence Interval (CI)-92.10-95.26) than for non diabetics (median-97.40: CI-96.45-98.67), U=101.00, n1=n2=25, p-value <0.001 [Table/Fig-3,4].

DISCUSSION

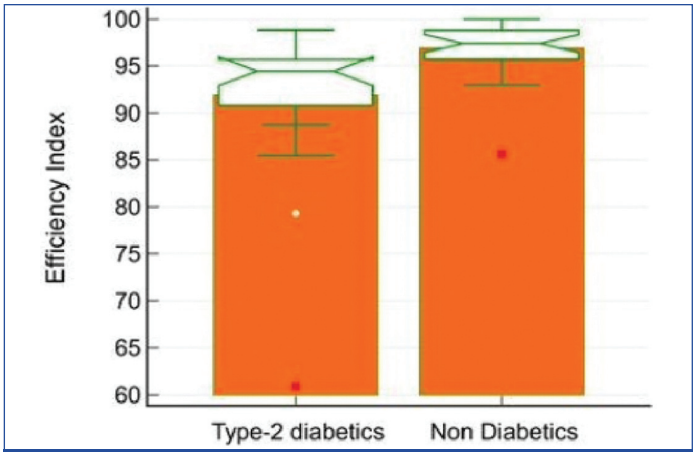
Distal symmetric sensorimotor polyneuropathy is a most common complication of DM. Early diagnosis of DPN can decrease morbidity, by intervening potential therapies and patient education.

Variables	Type 2 diabetics (Mean±SD)	Non diabetics (Mean±SD)	p-value
Age (years)	57.16±9.54	54.15±5.526	0.426
Duration of diabetes (years)	7.48±5.10	NA	NA
Fasting blood sugar (mg/dL)	148.4±46.19	NA	NA
Postprandial blood sugar (mg/dL)	242.56±86.79	NA	NA
HbA1c (%)	8.36±1.88	NA	NA
Random blood sugar (mg/dL)	NA	101.1±16.11	NA

[Table/Fig-2]: Baseline characteristics of type 2 diabetics (n=25) and non diabetics (n=25).

Variable	T2DM (n=25) median (CI)	Non diabetics (n=25) median (CI)	U value	p-value
Efficiency Index (EI)	94.46 (92.10-95.26)	97.40 (96.45-98.67)	101	<0.001

[Table/Fig-3]: Comparison of Efficiency Index (EI) as determined by bimanual hand coordination among T2DM and non diabetics.
Mann-Whitney test



[Table/Fig-4]: Comparision of Efficiency Index (EI) determined by bimanual hand coordination among type 2 diabetics and non diabetics.

The neuropathy in diabetes mostly affects the sensory and motor component of both upper and lower limbs. In the present study, bimanual hand coordination test was used to determine the EI among the type 2 diabetics and non diabetics. The findings showed a significant decrease (p-value <0.001) in EI of type 2 diabetics compared to the non diabetics thus, indicating delay in completion of the task and increase in error committed during completion of the task. Study on bimanual coordination has followed the patterns of cyclic movements like finger tapping with one hand while tracing circle with other [18]. Two studies have shown performance index as means to quantify bimanual coordination performance which is dependent on total time and error committed [19,20]. In the present study, bimanual coordination was assessed by EI which is dependent on total time and error committed in completion of task.

The possible explanation for decrease in efficiency of bimanual coordination among T2DM may be attributed to abnormal cross linking of collagen fibres in muscle and associated structures, due to accumulation of advanced glycosylation end products which affects the strength and leads to decrease in hand functions [21]. The delay in performance of the task and error committed affects the activities of daily living that involve coordinated movement of both the hands [22,23]. There is a decrease in interlimb coordination in diabetics which occurs at a slower pace and the patient is unaware of the damage [24]. The muscle weakness that is associated with diabetes in humans is attributed to combination of distal neuropathy and changes that occur in the muscle itself which include accumulation of fat deposits [25]. The decrease in coordination movements together with DPN may increase risk for functional dependency in T2DM [10]. Along with effect of diabetes on peripheral nervous system, diabetes also effects the central nervous system. Studies have shown that, high glycaemic changes, especially recurrent

hyperglycaemic attacks are very seriously associated with structural changes in the brain [26-29].

The Research Society for the Study of Diabetes in India (RSSDI) in its publication [30,31] on the clinical practice recommendations for the management of T2DM, recommends ophthalmic examination, the cardiovascular system, foot examination, renal function test frequently but, examination of the hand for hand functions and bimanual coordination is seldom mentioned. The findings of the present study indicate the need to include testing of hands and also bimanual coordination routinely so that, an early intervention can improve hand functions and quality of life among T2DM.

Limitation(s)

The current study's findings cannot be extrapolated to a larger population, but they can be used as a pilot study to study a larger sample size and provide more evidence. Future research should account for other confounding factors that may interfere with hand functions in T2DM patients.

CONCLUSION(S)

Bimanual coordination is very important to carry out day-to-day tasks. The present study showed that, the efficiency of bimanual coordination decreased in T2DM patients. This may affect the hand functions in T2DM patients. The findings of the present study indicate the importance of routinely testing hands and bimanual coordination alongside ophthalmic examination cardiovascular system, foot examination, and renal function test as clinical practice recommendations for the management of T2DM, So that, early intervention can improve hand functions and quality of life in T2DM patients.

Acknowledgement

The present study has been approved and accepted for ICMR STS 2019.

REFERENCES

[1] Mathur P, Leburu S, Kulothungan V. Prevalence, awareness, treatment and control of diabetes in India from the countrywide National NCD Monitoring Survey. Front Public Health. 2022;10:205.
[2] Jasmine A, Akila GV, Durai V, Anitha Rani M, Shriraam V, Samya V, et al. Prevalence of peripheral neuropathy among type 2 diabetes mellitus patients in a rural health centre in South India. Int J Diabetes Dev Ctries. 2021;41:293-300.
[3] Callaghan BC, Cheng HT, Stables CL, Smith AL, Feldman EL. Diabetic neuropathy: Clinical manifestations and current treatments. Lancet Neurol. 2012;11(6):521-34.
[4] Bastyr III EJ, Price KL, Bril V, MBBQ Study Group. Development and validity testing of the neuropathy total symptom score-6: questionnaire for the study of sensory symptoms of diabetic peripheral neuropathy. Clin Ther. 2005;27(8):1278-94.
[5] Barrett AM, Lucero MA, Le T, Robinson RL, Dworkin RH, Chappell AS. Epidemiology, public health burden, and treatment of diabetic peripheral neuropathic pain: A review. Pain Med. 2007;8(suppl_2):S50-62.
[6] Cederlund RI, Thomsen N, Thrainsdottir S, Eriksson KF, Sundkvist G, Dahlin LB. Hand disorders, hand function, and activities of daily living in elderly men with type 2 diabetes. J Diabetes Complications. 2009;23(1):32-39.
[7] Bansal V, Kalita J, Misra UK. Diabetic neuropathy. Postgrad Med J. 2006;82(964):95-100.
[8] Li K, Wei N, Cheng M, Hou X, Song J. Dynamical coordination of hand intrinsic muscles for precision grip in diabetes mellitus. Sci Rep. 2018;8(1):01-03.
[9] Rota E, Morelli N. Entrapment neuropathies in diabetes mellitus. WJD. 2016;7(17):342.
[10] Kim RP, Edelman SV, Kim DD. Musculoskeletal complications of diabetes mellitus. Clin Diabetes. 2001;19(3):132-35.
[11] Swinnen SP, Gooijers J. Bimanual coordination. Brain mapping: An encyclopedic Reference. Academic Press; 2015;2:475-82.
[12] Moes P, Jeeves MA, Cook K. Bimanual coordination with aging: Implications for interhemispheric transfer. Dev Neuropsychol. 1995;11(1):23-40.
[13] Duff SV. Impact of peripheral nerve injury on sensorimotor control. J Hand Ther. 2005;18(2):277-91.
[14] Eliassen JC, Baynes K, Gazzaniga MS. Anterior and posterior callosal contributions to simultaneous bimanual movements of the hands and fingers. Brain. 2000;123(12):2501-11.
[15] Mueller KLO, DeBoard Marion S, Paul LK, Brown WS. Bimanual motor coordination in agenesis of the corpus callosum. Behav Neurosci. 2009;123(5):1000-11.
[16] Darivemula S, Nagoor K, Patan SK, Reddy NB, Deepthi CS, Chittooru CS. Prevalence and its associated determinants of Diabetic Peripheral Neuropathy (DPN) in individuals having type-2 diabetes mellitus in Rural South India. Indian J Community Med. 2019;44(2):88.
[17] Shetty AK, Shankar V, Annamalai N. Bimanual coordination: influence of age and gender. J Clin Diagn Res. 2014;8(2):15.
[18] Fagard J, Hardy-Léger I, Kervella C, Marks A. Changes in interhemispheric transfer rate and the development of bimanual coordination during childhood. J Exp Child Psychol. 2001;80(1):01-22.
[19] Riquelme I, Arnould C, Hatem SM, Bleyenheuft Y. The two-arm coordination test: Maturation of bimanual coordination in typically developing children and deficits in children with unilateral cerebral palsy. Dev Neurorehabilit. 2019;22(5):312-20.
[20] Lefebvre S, Laloux P, Peeters A, Desfontaines P, Jamart J, Vandermeeren Y. Dual-tDCS enhances online motor skill learning and long-term retention in chronic stroke patients. Front Hum Neurosci. 2013;6:343. Doi: 10.3389/fnhum.2012.00343.
[21] Rhee SY, Kim YS. The role of advanced glycation end products in diabetic vascular complications. Diabetes Metab J. 2018;42(3):188-95.
[22] Krishnan V, Jaric S. Effects of task complexity on coordination of inter-limb and within-limb forces in static bimanual manipulation. Mot Control. 2010;14(4):528-44.
[23] Swinnen SP, Wenderoth N. Two hands, one brain: Cognitive neuroscience of bimanual skill. Trends Cogn Sci. 2004;8(1):18-25.
[24] Muramatsu K. Diabetes mellitus-related dysfunction of the motor system. Int J Mol Sci. 2020;21(20):7485.
[25] Hilton TN, Tuttle LJ, Bohnert KL, Mueller MJ, Sinacore DR. Excessive adipose tissue infiltration in skeletal muscle in individuals with obesity, diabetes mellitus, and peripheral neuropathy: Association with performance and function. Phys Ther. 2008;88:1336-44.
[26] Tehrani-Doost M, Qavam SE, Arzaghi SM, Larijani B. Association of diabetes mellitus and structural changes in the central nervous system in children and adolescents: A systematic review. J Diabetes Metab Disord. 2017;16(1):10.
[27] Gonder-Frederick LA, Zrebiec JF, Bauchowitz AU, Ritterband LM, Magee JC, Cox DJ, et al. Cognitive function is disrupted by both hypo- and hyperglycemia in school-aged children with Type 1 diabetes: A field study. Diabetes Care. 2009;32:1001-06.
[28] Reaven GM, Thompson LW, Nahum D, Haskins E. Relationship between hyperglycemia and cognitive function in older NIDDM patients. Diabetes Care. 1990;13:16.
[29] Perantie DC, Wu J, Koller JM, Lim A, Warren SL, Black KJ, et al. Regional brain volume differences associated with hyperglycemia and severe hypoglycemia in youth with Type 1 diabetes. Diabetes Care. 2007;30:2331-37.
[30] Chawla R, Madhu SV, Makkar BM, Ghosh S, Saboo B, Kalra S. RSSDI-ESI clinical practice recommendations for the management of type 2 diabetes mellitus 2020. Indian J Endocrinol Metab. 2020;24(1):1.
[31] Bajaj S. RSSDI clinical practice recommendations for the management of type 2 diabetes mellitus 2017. Int J Diabetes Dev Ctries. 2018;38(1):01-15.

PARTICULARS OF CONTRIBUTORS:
1. Undergraduate, Department of Physiology, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India.
2. Associate Professor, Department of Physiology, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India.
3. Associate Professor, Department of Physiology, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India.
4. Professor, Department of Medicine, Sri Devaraj Urs Medical College, SDUAHER, Kolar, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Ashwini K Shetty,
Associate Professor, Department of Physiology, Sri Devaraj Urs Medical College, SDUAHER, Kolar-563101, Karnataka, India.
E-mail: ashshetty31@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Dec 22, 2022
- Manual Googling: Mar 10, 2023
- iThenticate Software: Mar 31, 2023 (6%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Dec 21, 2022**
Date of Peer Review: **Feb 09, 2023**
Date of Acceptance: **Apr 01, 2023**
Date of Publishing: **Jun 01, 2023**