International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Auditory and Visual Reaction Time - A Tool for Early Detection of Neuropathy in Diabetics

Shweta Patil[1], Sangita Phatale[2]

[1]Tutor, Dept. of Physiology, Gulbarga Institute of Medical Sciences, Gulbarga, Karnataka.
[2]Professor, Dept. of Physiology, MGM Medical College, Aurangabad, Maharashtra. India.

Corresponding Author: Shweta Patil

Received: 22/02/2015 *Revised: 24/03/2015* *Accepted: 26/03/2015*

ABSTRACT

Introduction: Chronic hyperglycemia in diabetes is associated with neuropathy. It affects peripheral nerves in the somato-sensory system and slows psychomotor responses which may affect reaction time. Reaction time is a simple and non-invasive test for peripheral and central neural structures. In view of this the present study is done to assess and compare auditory and visual reaction time in diabetics and normal adults.

Materials and methods: The study was conducted at Basaveshwar teaching and general hospital, Gulbarga. 60 well controlled diabetic subjects without complications (duration of disease1-5 years as group 1 and 5-10 years as group-2) comprised the study group and 30 age and sex matched normal healthy individuals were included in the control group The visual reaction time for green and red light and auditory reaction time for tone and click sound was measured by using reaction time apparatus 2x4.

Results: Both visual and auditory reaction times were prolonged in diabetics with P<0.0001, which is statistically highly significant.

Discussion and Conclusion: The raised blood glucose in diabetes causes chemical changes in nerves and damages blood vessels that carry oxygen and nutrients to the nerves. Hyperglycaemic pathological changes intrinsic to the neurons and ischemic induced neuronal damage by decreased neurovascular blood flow may be responsible for reduced nerve conduction. Long standing hyperglycemia will also lead to a metabolic cascade that causes peripheral nerve injury. The axonal degeneration, axonal shrinkage, and thickening of basement membrane are responsible for delayed motor conduction and hence, delayed reaction time. Delayed reaction time in diabetics without clinical neuropathy can be taken as a non-invasive, low cost, sensitive indicator of early nerve damage without clinical signs and symptoms and hence, can be used as a routine screening test.

Key words: hyperglycemia, neuropathy, reaction time

INTRODUCTION

Diabetes mellitus is a global problem, as of 2010, an estimated 285 million people had diabetes, with type 2 constituting 90% of the cases. [(1)] Its incidence is increasing rapidly, and by 2030, this number is estimated to almost double. [(2)] The largest increase in prevalence will take place in the regions dominated by developing economies [(3)] and Asia accounts for 60% of world's diabetic population. The increase in the prevalence of diabetes is due to population growth, aging, economic development, urbanisation and lifestyle changes, perhaps most importantly a “western-style diet”, and an increase of obesity and physical inactivity. [(4)]

It is one of the leading causes of mortality and morbidity in India, which is due to high levels of blood glucose. [(5)] Close to four million deaths in the 20-79 age groups may be attributable to diabetes in 2010, accounting for 6.8% of global all-cause mortality in this age group. Diabetic neuropathy is an important cause of sudden deaths in diabetics and is said to be dependent both on degree of control and duration of diabetes, though the onset of this complication is more related to duration of diabetes.

Reaction time is the interval between the application of stimulus (eg: light or sound) and appearance of appropriate voluntary responses in a subject. Auditory and visual reaction time is considered as an ideal tool for measuring sensory motor association and performance of an individual. It has physiological significance and is a simple and non-invasive test for peripheral and central neural structures.

MATERIALS AND METHODS

The study was conducted on 90 subjects aged between 40-50 years after obtaining the permission of the ethical committee of our institution. The study group consisted of 60 diabetic patients with history of diabetes for 1-10 years attending the medical OPD of Basaveshwar teaching and general hospital, Gulbarga and controls were 30 age and sex matched healthy individuals from the non-teaching staff of M.R. Medical College, Gulbarga. 30 diabetic patients with duration of the disease from 1-5 years were grouped as group-1 and 30 diabetic patients with duration of the disease from 5-10 years were grouped as group-2. Diabetics with auditory or visual disturbance, Alcoholics, hypertensives, smokers, Clinical evidence of peripheral neuropathy, Muscle weakness, myopathy, Mental or psychological disorders, Neurovascular complications, Any pathology or injury to the upper limb and Clinical evidence of any other illnesses which effect the reaction time were excluded from the study.

The Auditory and visual reaction time was measured by using reaction time apparatus. This apparatus is a portable research reaction timer with 2 response choices. It has an inbuilt chronoscope-4 digit chronoscope with least count of 1/1000 seconds and works on 230 volts AC. The apparatus has two sides, one ‘S’s (Subject) and the other ‘E’s (Examiner). There are 4 keys, and 4 selector switches on ‘E”s side for selecting ‘S’s left or right key. When the key marked green light is pressed on the ‘E’s side ‘S’ will see the same on his side; similarly for the red light, buzzer and click. The push button on E’s side rings the bell. This is a signal for S to press the right or left key as selected by E’ with the selector switch. Then E presses any of the keys giving the required stimulus. The stimulus key is double key. It gives the stimulus and also starts the chronoscope. As soon as the stimulus is received S lifts his finger from the right or left key. This stops the chronoscope and thus reaction time to any of the stimuli is obtained. All the subjects are thoroughly acquainted with apparatus and 3 readings were taken after practice trials for 4 stimuli i.e.; Red and Green colour for visual reaction time, Tone and Click for Auditory reaction time. Reaction time was recorded using the dominant hand.

RESULTS

Table 1: Comparison of Visual and Auditory Reaction Time in Study and Control Group

Reaction Time (msec)		Control group (30) Mean±SD	Study Group (60) Mean±SD	t-test	P-Value
Visual	**Green**	0.246±0.0322	0.283±0.0344	t=5.138	P<0.001
	Red	0.194±0.028	0.233±0.026	t=6.39	P<0.001
Auditory	**Tone**	0.1932±0.0156	0.195±0.028	t=0.67	P>0.05
	Click	0.159±0.0155	0.1854±0.020	t=22.4	P<0.001

P<0.001------ Extremely significant

Table 2: Comparison of Visual and Auditory Reaction Time In Group-1 And Group-2 Diabetics

Reaction Time (msec)		Group-1 (30) MEAN±SD	Group-2 (30) MEAN±SD	t-test	P-VALUE
Visual	GREEN	0.274±0.033	0.294±0.038	t=2.17	P<0.05
	RED	0.228±0.0287	0.236±0.022	t=1.78	P>0.05
Auditory	TONE	0.1891±0.0161	0.197±0.014	t=1.92	P>0.05
	CLICK	0.1785±0.021	0.1923±0.0169	t=3.36	P<0.05

Statistical analysis of the data was done using student ‘t’ test and p value < 0.05 was considered significant.Table-1 depicts the comparison of VRT and ART in controls and diabetics. Controls performed better than the diabetics for visual green and red light stimuli and ART for click sound stimuli at P< 0.001 for both. The reaction time for auditory tone sound, though more in diabetics was not found to be statistically significant. From the above table it can also be seen that ART is faster than VRT in both diabetics as well as controls.

Table-2 depicts comparison of VRT and ART in group-1 and group-2 diabetics. Group-1 diabetics performed better than Group-2 diabetics for visual green light stimuli and ART for click sound stimuli with p<0.05, which is statistically significant. The reaction time for visual red light and auditory tone sound, though more in group-2 was not statistically significant.

DISCUSSION

The results of our study in 90 subjects (60 diabetics with and 30 healthy controls) indicate that there is a significant prolongation of both VRT and ART in diabetics as compared to normal healthy adults. The possible mechanism being that, the raised blood glucose associated with diabetes causes chemical changes in nerves and damages blood vessels that carry oxygen and nutrients to the nerves. Excessive glucose metabolism causes decrease in the NO in nerves that dilates blood vessels, and low levels of NO may lead to constriction of blood vessels supplying the nerves in diabetic patients. The perfusion deficit is sufficient to cause endoneurial hypoxia. These early events occur well before the development of clear pathological alterations to nerve capillaries such as basement membrane thickening, and are accompanied by functional deficits such as reduced NCV and increased resistance to ischaemic conduction failure, hence increased reaction time.

Our study is in accordance with the study of other authors. [6,7] Dobrazanski et al, found a doubling of visual reaction time in diabetics (473ms) versus that measured in healthy individuals (216ms). [8] The comparison between IDDM and NIDDM revealed delayed reaction time in IDDM, but this difference was not statistically significant. [7] On the contrary Samantha J Richerson, Charles J Robinson and Judy Shum found no significant differences in ART between mature adults with or without diabetes and their young adult counterparts. [9]

We also found that the VRT was longer than the ART. This may be due to the fact that the VRT involves chemical changes in its occurrence and the visual pathway has many collateral pathways to various association areas and hence a greater delay in comprehension of visual stimulus. Reaction time is dependent on several factors like arrival of stimulus at the sensory organ, conversion of the stimulus by the sensory organ to a neural signal, neural transmissions and processing, muscular activation, soft tissue compliance, and the external measurement parameter. The auditory stimulus takes only 8-10 milliseconds to reach the brain, but on the other hand a visual stimulus takes 20-40 milliseconds. (10) This implies that the faster the stimulus reaches the motor cortex, faster will be the reaction time to the stimulus. Therefore since auditory stimulus reaches the cortex faster than the visual stimulus the auditory reaction time is faster than the visual reaction time.

Mohan et al studied visual and auditory reaction times in patients of diabetes mellitus and aged matched normal controls and found that, ART was shorter than VRT in controls as well as diabetics. In diabetic patients, there was significant prolongation of both VRT and ART. (11) Other authors have also found VRT to be longer than auditory reaction time. (12-14) On the contrary, researches done by Yagi et al, show that reaction time to visual stimuli is faster than the auditory stimuli. (15)

The VRT and ART in group-1 diabetics (duration of diabetes 1-5 years) is faster than in group-2 diabetics (duration of diabetes 5-10 years).As a consequence of longstanding hyperglycemia, a downstream metabolic cascade leads to peripheral nerve injury through an increased flux of the polyol pathway, enhanced advanced glycation end-products formation, excessive release of cytokines, activation of protein kinase C and exaggerated oxidative stress. Extremely long axons originating in the small neuronal body are vulnerable on the most distal side as a result of malnutritional axonal support or environmental insults. Sparse vascular supply with impaired autoregulation is likely to cause hypoxic damage in the nerve. Such dual influences exerted by long-term hyperglycemia are critical for peripheral nerve damage, resulting in distal-predominant nerve fiber degeneration. The axonal degeneration of both the myelinated and unmyelinated fibers, axonal shrinkage, thickening of the basement membrane and microthrombi are responsible for delayed motor nerve conduction and hence, the increased reaction time. (16)

In a study by Partanen J et al, patients with NIDDM and controls were followed for a period of 10 years. At the start 8.3% of patients had neuropathy as compared to 2.3% in controls. After 10 years the prevalence of neuropathy was 41.9% in diabetics and 5.8% in controls and those with neuropathy had poor glycemic control than those without, thus concluding that the incidence of neuropathy in NIDDM increases with time. (17) Pitrat J, Padilla-Medina JA et al, also found that the risk for complications of neuropathy increases with increasing duration and severity of hyperglycemia. (18-20)

Chronic hyperglycemia is associated with neuropathy (21) and Cognitive dysfunction. The most common cognitive deficits identified in patients with diabetes are slowing of information processing speed (22-25) and worsening psychomotor efficiency (23,24,26) all of which affect the reaction time. The inability to differentiate cognitive dysfunction is the major drawback of this study.

CONCLUSION

We observed a prolonged visual and auditory reaction time in diabetics, which increased with the duration of the disease.

This increase in reaction time can be an early manifestation of diabetic peripheral neuropathy. Thus we conclude that reaction time can be used as a simple and non invasive routine screening test for early detection of neuropathic changes in diabetics. Further studies with a larger sample size including tests for ruling out cognitive dysfunction are required to substantiate our findings before a firm conclusion can be drawn.

REFERENCES

1. Williams textbook of endocrinology (12th ed.). Philadelphia: Elsevier/ Saunders. pp. 1371–1435. ISBN 978-1-4377-0324-5.
2. Wild S, Roglic G, Green A, Sicree R, King H (2004). "Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030". Diabetes Care 27 (5): 1047–53.
3. International Diabetes Federation. The Diabetes Atlas. Third Edition. Brussels: International Diabetes Federation; 2006.chapter 1: 16-23
4. Chan JC, Malik V,Jia w, et al. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. JAMA 2009;301:2129–2140
5. Shervin R.S. Diabetes Mellitus. Cecil text book of medicine, 2004; 22 edition, vol-1:1441-1443.
6. Prabhjot Kaur, Maman Paul, Jaspal Singh Sandhu. Auditory and Visual reaction time in athletes, healthy controls and patients of type1 diabetes mellitus: A Comparative Study. International Journal of Diabetes in Developing Countries 2006; 26(3):112-115
7. Parekh N, Gajbhiye IPR, M Wahane, Titus J. The study of Auditory and Visual Reaction Time in Healthy Controls, Patients of Diabetes Mellitus on Modern Allopathic Treatment, and those Performing Aerobic Exercises. Journal Indian Academy of Clinical Medicine 2004; 5 (3):239-243
8. Dobrzanski T, Rychta T. Studies on the time of simple reaction and selective reaction in diabetes and schizophrenia. Polish Medical Journal. 1968;7:442–448.
9. Samantha J Richerson, Charles J Robinson, and Judy Shum. A comparative study of reaction times between type II diabetics and non-diabetics. Biomed Eng Online. 2005; 4: 12.
10. Kemp, B. J. Reaction time of young and elderly subjects in relation to perceptual deprivation and signal-on versus signal-off condition. Developmental Psychology1973*:* 8: 268-272.
11. Mohan. M, Thombre. DP, Das, AK, Subramanian N, Chandrashekar S. Reaction Time in Clinical Diabetes Mellitus. Indian J Physiol Pharmacol 1984; 28 (4):311-314.
12. Niruba R and Maruthy KN. Assessment of Auditory and Visual Reaction Time in Type 2 Diabetics. Al Ameen J Med Sci 2011; 4 (3):274-279.
13. Holmes E, Tsalikian, Yamada T. Blood Glucose Control and Visual and Auditory Attention in Men with Insulin-dependent DiabetesC. Diabetic Medicine 1988;5(7): 634 - 639
14. Robinson, E. S. Work of the integrated organism. In C. Murchison (Ed.), Handbook of General Experimental Psychology, Clark University Press, Worcester, MA1934.
15. Y. Yagi, K. L. Coburn, K. M. Estes and J. E. Arruda, “Effects of Aerobic Exercise and Gender on Visual and Auditory P300, Reaction Time, and Accuracy,” European Journal of Applied Physiology, Vol. 80, 1999, pp. 402- 408.
16. Frier BM, Truswell AS, Shephered J. Diabetes mellitus. Haslett C, Hunter JAA, Boon NA, editors. Davidson's Principle and Practice ofMedicine. 18th ed. 1999; p 471-508.
17. Partanen J, Niskanel L. Natural History of Peripheral Neuropathy in patients with NIDDM. NEJM,1995 July;13, 333(2): 89-94.

18. Pirart J: Diabetes mellitus and its degenerative complications: a prospective study of 4400 patients observed between 1947 and 1973. Diabetes Care 1978, 1:168-188. 252-263
19. Padilla-Medina JA, Prado-Olivarez J, Amador-Licona N, Cardona-Torres LM, Galicia-Resendiz D, Diaz-Carmona J. Study on simple reaction and choice times in patients with type I diabetes. Comput Biol Med. 2013 May 1;43(4):368-76.
20. Sanchez-Marin FJ, Padilla-Medina JA. Simple reaction times and performance in the detection of visual stimuli of patients with diabetes Comput Biol Med. 2010 Jun;40(6):591-6
21. McCall A, Figlewicz D: How does diabetes mellitus produce brain dysfunction? Diabetes Spectrum10: 25
22. Brands AM, Kessels RP, Hoogma RP, Henselmans JM, van der Beek Boter JW, Kappelle LJ, de Haan EH, Biessels GJ 2006 *Cognitive performance, psychological well-being, and brain magnetic resonance imaging in older patients with type 1 diabetes.* Diabetes 55:1800–*1806*
23. Ryan CM, Geckle MO, Orchard TJ 2003 *Cognitive efficiency declines over time in adults with type 1 diabetes: effects of micro- and macrovascular complications.* Diabetologia 46:940–*948*
24. Ryan CM, Williams TM, Finegold DN, Orchard TJ 1993 *Cognitive dysfunction in adults with type 1 (insulin-dependent) diabetes mellitus of long duration: effects of recurrent hypoglycaemia and other chronic complications.* Diabetologia 36:329–*334*
25. Wessels AM, Rombouts SA, Remijnse PL, Boom Y, Scheltens P, Barkhof F, Heine RJ, Snoek FJ *Cognitive performance in type 1 diabetes patients is associated with cerebral white matter volume.* Diabetologia, 2007; *20:*1763–*1769*
26. Weinger K, Jacobson AM, Musen G, Lyoo IK, Ryan CM, Jimerson DC, Renshaw PF 2008 *The effects of type 1 diabetes on cerebral white matter.* Diabetologia, 2008; 51:417–*425.*

How to cite this article: Patil S, Phatale S. Auditory and visual reaction time - a tool for early detection of neuropathy in diabetics. Int J Health Sci Res. 2015; 5(4):141-146.

****