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Original Research Article

A Comparative Study of Auditory and Visual Reaction Time in Patients with Type-II Diabetes Mellitus and Healthy Controls

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Abstract: Diabetic Peripheral Neuropathy (DPN) is one of the most common complications associated with Diabetes Mellitus. There are a number of investigative tools in the vast armamentarium of neurophysiology to evaluate and detect dysfunction in varied nerve fibers so implicated in diabetes mellitus. Auditory and visual reaction time is one such test for measuring sensory motor association. This study was aimed at evaluating the effect of Diabetes Mellitus on reaction time and the correlation of this effect with the duration of the disease. The study sample consisted of 120 male participants in the age group 30-50 years and were categorized as healthy controls (n=30) and participants with Type II Diabetes Mellitus, further subdivided into 3 subgroups based on the duration of the disease, viz, 0-3, 3-6 and 6 and above years, each having 30 participants. Auditory Reaction time was measured for low pitch and high pitch sounds and visual reaction time was measured for red light and green light. It was observed that both the auditory and visual reaction time was significantly high in diabetic patients as compared to that observed in the controls. On further analysis, the elevation in reaction time seemed to be linearly correlated with the time course of the disease, wherein the elevation in auditory reaction time could be appreciated only in the later stages of the disease. Subclinical neuropathy could hence be defined and profiled through simple and non invasive neurophysiological means of reaction time that could influence and/or modify the disease process of diabetes mellitus.
Keywords: Visual Reaction Time, Auditory Reaction Time, Diabetes Mellitus, Diabetic Peripheral Neuropathy.

INTRODUCTION

Diabetes Mellitus is among the leading causes of morbidity and mortality across the globe [1]. Its incidence is on the rise in the rapidly urbanizing world, due to lack of physical activity and increased stress levels [2]. It has been estimated that in 2014, 9% of the adult population, aged 18 and above, were diabetic and the disease was responsible for approximately 1.5 million deaths in 2012. The middle and low income countries are the worst hit, as more than 80% of the fatalities associated with diabetes have occurred in such countries [3, 4]. It is estimated that India would have a load of diabetic patients of approximately 79.4 million by 2030, a major share of the expected figure of around 366 million in the world for the same year [2].

Diabetes mellitus (DM) is an example of endocrine dysfunction in which glucose levels in the blood are elevated, either due to inadequate insulin secretion to the desired stimulus (Type 1) or due to inadequate action of the hormone at the periphery (Type 2). The symptom complex of impaired glucose metabolism, a cardinal feature of diabetes mellitus, is delineated by changes taking place at the microscopic and macroscopic levels affecting the physiology of the kidneys, eyes, vascular system, and nervous system [1].

Among the associated complications of the disease, Diabetic Peripheral Neuropathy (DPN) accounts for around 28% of the cases [5]. Neuropathy of diabetes mellitus is a slow unrelenting smoldering disease process, which is a culmination of several different pathological processes and often goes undetected for years [6]. The severity the disease is often related to the duration of the disease and degree of glycaemic control [7].

To maintain homeostasis, an individual has to cope with the changes in the external and internal environment. How well that homeostasis can be maintained depends on the integrity of communications between the cells and the responses given by the various systems in terms of sensory perception and motor response [8].

Reaction Time assay is a tool that can be used for evaluating the speed, dexterity and integrity of the neurophysiological processes underlying sensory motor association [9, 10].

It is the time duration between the presentation of a stimulus and the occurrence of the associated behavioral response. Being a simple non invasive test, it has physiological significance and is considered to be an index of the speed of the neurophysiological processing [11, 12].

Various studies have shown the influence of age, sex, body mass index and exercises on the speed of processing of an individual [11, 13, 14]. Neuro-degenerative diseases like Parkinson's disease, schizophrenia tend to worsen the reaction time [15, 16].

Certain occupations like drivers, pilots, doctors need to have a quicker response which can be assessed by reaction time [12]. This test could particularly be helpful to check if such professionals have some neurological impairment.

Studies have shown the detrimental effects of Diabetes Mellitus on the peripheral nerves in the somatosensory and auditory system. The disease has also been reported to slow the psychomotor responses, and to have cognitive effects, especially on those individuals who fail to attain proper metabolic control [17]. The nerve conduction velocities are also known to be reduced due to neuropathy [18, 19].

Various stimuli like visual, auditory, nociception, tactile or temperature change may be used to assess the reaction time in an individual [11]. The auditory and visual reaction time are the more pertinent ones to measure and may be helpful in determining the extent of the neurodegenerative changes that may have occurred. As there is scarcity of studies on the association of diabetes with the audio visual reaction time and the effect of the duration of the disease on this association, this study was undertaken to find out the effects of duration of diabetes mellitus on auditory and visual reaction time.

The aim of the study was to assess the auditory and visual reaction time in patients with type II diabetes mellitus and age matched healthy controls and to compare the reaction time within the diabetic patients with various durations of the disease and between the patients and healthy controls.

MATERIALS AND METHODS

The study was conducted in the Department of Physiology, in collaboration with the Department of Medicine, at S.M.S. Medical College and Attached Hospitals, Jaipur. Approval from the Institute Ethical Committee was taken before proceeding with the study. The study sample consisted of confirmed cases of Type II Diabetes Mellitus, attending the Diabetes Clinic at SMS Hospital, Jaipur and age and sex matched healthy controls. The controls were either healthy relatives of the patients or paramedical and support staff from different departments of the institute. Only male patients were included and females were excluded to omit the discrepancies seen in reaction time between the two genders. The diabetic patients were further subdivided, according to the duration of the disease, as: Group I, patients having the disease for 0 – 3 years; Group II, patients having the disease for 3-6 years and Group III, patients having the disease for 6 years and more.

The sample size was calculated 27 for each of the 4 groups at alpha error 0.05 and power 80%, assuming minimum difference of means to be detected in auditory reaction time, 0.023±0.025ms [17]. Sample size calculated as per other variables of study was less than 27 subjects for each group. So for the study purpose, 30 subjects with Type II Diabetes Mellitus for each of the 3 study groups and 30 age and sex matched healthy controls were taken. Patients with duration of diabetes more than 10 years were excluded to avoid further complications due to the disease. Alcoholics, smokers, subjects with a history of hypertension or clinical evidence of peripheral neuropathy or myopathy or with any pathology or injury to the upper limb were also excluded from the study. Subjects having auditory or visual disturbances for other reasons were not included.

The reaction time measurements were done using the Audiovisual Reaction Time apparatus (designed by Medisystem, Yamunanagar, Haryana). The subjects were informed about the complete procedure and about the purpose of the research and written consent was taken from the subjects before starting with the measurements. The subjects were instructed to have a light breakfast before reporting for the test. All the tests were carried out during morning hours in a quiet room. For Visual Reaction Time, red and green light stimuli were used and for the Auditory Reaction Time, low pitched and high pitched sounds were used. Three readings were taken for each parameter and the minimum reading was considered as the reaction time. The quantitative data was expressed in mean ± SD and significance of difference in means was inferred by ANOVA test (since there were more than two groups) and post – hoc Dunnett Test (for comparison within the groups). P Value of less than 0.05 ($P < 0.05$) was considered significant.

OBSERVATIONS AND RESULTS

The Age group taken for the study was 30 – 50 years and the mean age of the subjects in the different groups is shown in Table 1.

No significant difference was observed in the anthropometric measures of the subjects in any of the groups (Table 2).

Table-1: Age distribution within the groups

Group	N	Mean age (years)
Control	30	39.77 ± 6.99
Group I	30	40.20 ± 6.28
Group II	30	41.10 ± 5.11
Group III	30	46.23 ± 4.65

Table-2: Comparison of the anthropometric parameters within the groups

Group	Control	Group I	Group II	Group III	P Value[a]
Height (cm)	171.00 ± 4.95	169.57 ± 5.54	169.37 ± 7.21	167.13 ± 6.99	0.123*
Weight (kg)	72.80 ± 6.81	76.43 ± 10.39	72.46 ± 10.47	70.23 ± 10.93	0.058*
Body Mass Index (kg/m^2)	24.96 ± 2.72	26.54 ± 3.08	25.19 ± 2.79	25.07 ± 3.19	0.136*

[a]ANOVA test *P Value > 0.05: Insignificant

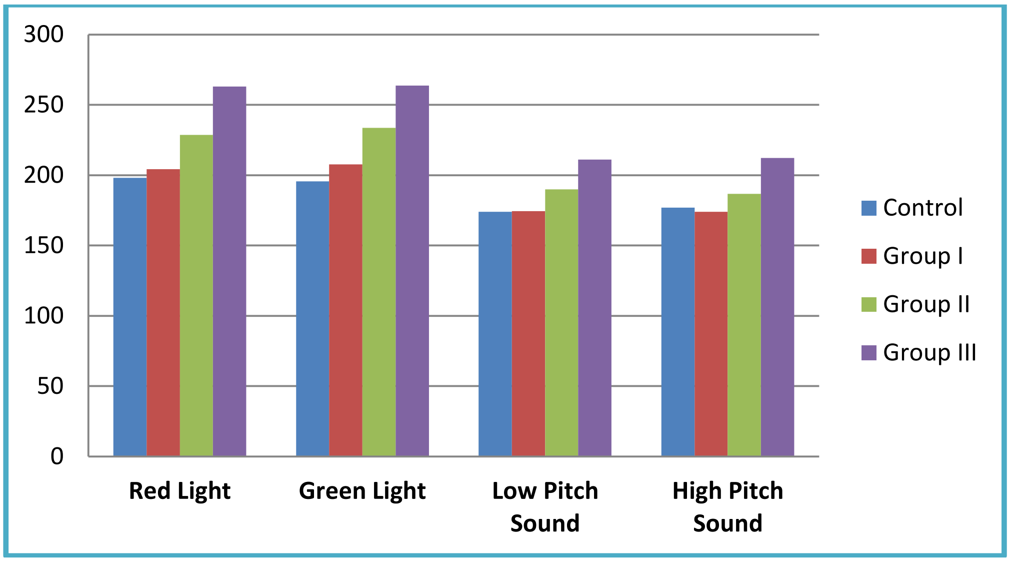

Fig-1: Comparison of Visual Reaction Time for Red Light between Control and Study groups

Table-3: Comparison of Visual Reaction Time for Red Light between Control and Study groups

Groups		Difference in mean (ms)	P Value[b]
Control	Group I	6.33	0.52*
	Group II	30.67	0.05**
	Group III	65.00	0.00**

[b]Post hoc Dunnett's test *P > 0.05: Insignificant **P < 0.05: Significant

Table-4: Comparison of Visual Reaction Time for Green Light between Control and Study groups

Groups		Difference in mean (ms)	P Value[b]
Control	Group I	12.00	0.13*
	Group II	38.00	0.00**
	Group III	68.00	0.00**

[b]Post hoc Dunnett's test *P > 0.05: Insignificant **P < 0.05: Significant

Table-5: Comparison of Auditory Reaction Time for Low Pitch sound between Control and Study groups

Groups		Difference in mean (ms)	P Value[b]
Control	Group I	0.33	0.97*
	Group II	16.00	0.06*
	Group III	37.00	0.00**

[b]Post hoc Dunnett's test
*P > 0.05: Insignificant **P < 0.05: Significant

Table-6: Comparison of Auditory Reaction Time for High Pitch sound between Control and Study groups

Groups		Difference in mean (ms)	P Value[b]
Control	**Group I**	-3.00	0.61*
	Group II	9.67	0.11*
	Group III	35.33	0.00**

[b]Post hoc Dunnett's test *P > 0.05: Insignificant **P < 0.05: Significant

DISCUSSION

In the present study, it was observed that the reaction time for both the visual and the auditory stimuli was higher in diabetic subjects as compared to the healthy controls (figure 1), an observation that could probably be the result of a delay in the motor nerve conduction velocity due to the axonal degeneration, axonal shrinkage, axonal fragmentation and the degeneration of the basement membrane [8]. The raised blood glucose levels induces a decrease in the levels of Nitric Oxide, leading to a propensity towards vasoconstriction of blood vessels supplying the nerves, resulting in hypoxia and associated pathologic changes in the nerves [17]. Similar results have been reported by Niruba *et al*. [11] and Mungal *et al*. [12].

When the different groups were compared to the control group, no significant change could be appreciated in the reaction time between the controls and Group I subjects (i.e., having diabetes mellitus for 1 – 3 years) for both the auditory and visual stimuli (table 3-6), profiling the long drawn out time course of the degenerative processes of diabetes mellitus. However, the visual reaction time (for both the red light and green light stimuli) was significantly elevated in the subjects having diabetes mellitus for 3 – 6 years (Group II) and for subjects having the disease for more than 6 years (Group III) as compared to that observed in the Control group (Table 3, 4) and the reaction time in case of the auditory stimuli, for both high pitch and low pitch sound, was elevated significantly only in Group III subjects and not in the group II subjects, when compared to that observed in control group (Table 5, 6), suggesting that the visual system could be affected earlier by the degenerative changes of diabetes mellitus than the auditory system.

A progressive worsening of both the auditory and the visual reaction time was observed in the diabetic patients with the progression of the disease (figure 1). This can be explained by the fact that the severity of neuropathy increases with the duration of the disease, as has been previously observed by Pirart [20] and Partanen *et al*. [21]. Also, the nerve conduction velocities, which tend to depress with the duration of diabetic neuropathy [22], may be responsible for this worsening of reaction time. This is consistent with the observation of Gupta *et al*. [17], who found a similar worsening in the reaction time with the duration of the disease.

The results of this study show that the auditory and visual reaction time in diabetic patients is elevated as compared to that observed in healthy controls and the elevation in the reaction time tends to worsen with disease progression. Also, the visual reaction time tends to be affected before the auditory reaction time. This elevation in the reaction time may serve as an indicator of the onset of neuropathy, as the clinical symptoms have been reported to appear at a very late stage.

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