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Research Article

Exploring the Relationship between Balance and Cognition in Middle-Aged Individuals with Diabetes and Hypertension: A Cross-sectional Study

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I N F O

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A B S T R A C T

Background: Diabetes and hypertension are commonly occurring non-communicable diseases across the world. India is known as the diabetes capital of the world since more than 62 million individuals are presently suffering from diabetes. The risk of dementia increases in individuals with type 2 diabetes mellitus (DM). Similarly, in individuals with hypertension (HTN), there is an increased risk of balance impairment due to reduced sensory inputs from peripheral nerves to the CNS. This study has been taken up to evaluate the correlation between balance and cognition in the adult Indian population suffering from diabetes and hypertension using the Berg Balance and Montreal Cognitive Assessment scale.

Method: Two hundred and ninety-eight middle-aged individuals were screened for hypertension and/ or diabetes mellitus for this cross-sectional study. Each subject was assessed for balance and cognition using the Berg Balance Scale and Montreal Cognitive Assessment scale respectively. The data that were obtained were tabulated and analysed.

Result: The Pearson correlation analysis suggested a negative correlation between diastolic blood pressure (DBP) and cognition ($r = -0.267$; $p = 0.020$) indicating that higher DBP causes cognition to deteriorate in hypertensive patients. It was seen that an increase in systolic blood pressure correlated with a decline in cognitive ability among diabetic people.

Conclusion: Hypertension with increased diastolic pressure results in detrimental cognitive decline. No correlation was found between systolic blood pressure (SBP), DBP and balance. An increase in the glycaemic level affects cognitive ability and increases the risk of falls.

Keywords: Hypertension, Diabetes Mellitus, Balance, Cognition, MoCA, Berg Balance Scale

Introduction

In India, diabetes mellitus (DM) is on the verge of becoming an epidemic. As of now, diabetes has been identified in about 62 million individuals.[1] However, this number is expected to rise to 79.4 million by the year 2030. According to a previous study, in 2019, it was estimated that 9.3% of people (463 million) had diabetes all over the world, and this number is expected to increase to 10.2% by 2030 and 10.9% by 2045.[2] According to the data from the National Family Health Survey (NFHS-5), in Karnataka, the prevalences of hypertension (HTN) and DM are 14.8% and 25.9%, respectively, in 2022. Almost one-third of older adults with diabetes were found to be at risk of cognitive impairment.[3] The prevalence of HTN currently is 26% which is estimated to elevate by 29% by the year 2025.[3] The relative cause of this could be vascular pathology associated with diabetes. The underlying mechanism is impaired neurogenesis, changes in the blood-brain barrier and transport functions of cerebral vasculatures, reduced antioxidant capacity and elevated pro-inflammatory cytokines. Another theory proposes that glucose imbalances impede the synthesis of acetylcholine, which is essential for cognitive function and is produced by insulin-regulated acetylcholine transferase expression.

Out of 1,692 diabetic individuals, 423 experienced falls, which is a rate of 25.0%. In comparison, out of 13,011 non-diabetic individuals, 2,368 experienced falls, which is a rate of 18.2%. Therefore, diabetes mellitus was found to be associated with a higher risk of falls. The risk of falls was found to increase by 94% in insulin-treated patients and by 27% in non-insulin-treated patients with diabetes.[4] Segmental demyelination of peripheral nerves and demyelination of vestibular or visual nerves reduces sensory input to CNS leading to postural sway, loss of balance and falls. In Karnataka, it is about 18%. Arterial hypertension affects cognition, and prior research has shown a connection between high blood pressure in middle age and cognitive deterioration for the next 20 to 30 years.[3]

There is a clear association of diabetes and hypertension with cognitive decline, although the results for obesity and dyslipidaemia were less conclusive in a study.[5] Even though individuals with diabetes and normal cognitive function had similar initial cognitive scores, they were found to experience a decline in cognitive performance over four years, unlike those with normal glucose or impaired fasting glucose.[6] A study found that the incidence rate of falls was significantly higher in individuals with DM (78%) compared to those without DM (30%).[7] Elevated hypertension levels increase the formation of ischaemic white matter lesions due to vascular atrophy. Prevalence of falls was reported to be about 32% in 2021 globally in hypertensive patients.[8] Hypertension negatively affects balance by damaging large arteries and decreasing micro-circulation leading to micro infarct damaging inter-neural connections. As a result of this process, the ability to receive environmental and peripheral structural impulses is impaired, which in turn, lowers the capacity to keep a stable posture.[9] Several studies have reported that the older adult population with HTN and subjects with DM show an association with cognitive impairment and balance loss. There is a dearth of literature which states the association of DM and HTN with balance, coverage balance and cognition individually and in conjunction in the middle-aged population. Therefore, it is essential to explore this area and add to the knowledge of research. This will help in the prevention and implementation of early intervention leading to a better quality of life, reduction in the disability rate, and avoidance of complications induced due to the same.

Methodology

This cross-sectional observational study persisted for two years from May 2019, and 298 individuals were screened for hypertension or diabetes mellitus using an open-ended sample size method. The study was conducted at a tertiary care hospital, urban health care centre, and health camps in Belagavi. The study was ethically cleared by the Institutional Ethics Committee. The participants were individuals over 18 years old who were able to follow commands and were either diagnosed with HTN or type 2 diabetes mellitus (T2DM) or had neither/ either of them. Participants with musculoskeletal conditions, neurological conditions, psychological conditions, or recent lower limb surgeries were excluded. The participants were given a brief explanation of the study, and consent was obtained from them. The values and results of blood pressure (BP), Montreal Cognitive Assessment (MoCA), HbA1c, and Berg balance tests of the participants were assessed. One assessor assessed the blood pressure, while the remaining assessors assessed the other parameters for all participants. The data were tabulated and analysed. Statistical analysis was performed and mean and SD were calculated for demographic data. Pearson correlation test was performed to establish the correlation between variables and t test was performed for comparing the data of groups.

Results

The study had 298 participants, out of which 136 (45.6%) were men and 162 (54.4%) were women. The average age of the participants was 51.63 ± 13.26 years, indicating that most of the participants were in their middle age. Among the 298 participants, 149 were diagnosed with HTN, 90 were diagnosed with T2DM, and 34 had both HTN and T2DM. The remaining 59 participants were considered healthy individuals. Participants with high blood pressure had a mean value of 140.77/ 88.12 ± 22.59/ 14.30 mm of Hg, whereas those with hyperglycaemia had a mean HbA1c value of 8.24% (SD = 1.96) (Table 1).

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Table 1.Demographic Characteristics

Variables		Frequency (n)	Percentage	Variables	Mean	SD
Gender	Male	136	45.6	Age (years)	51.63	13.26
	Female	162	54.4			
HTN and DM	Yes	34	11.4	SBP	140.77	22.59
Blood pressure	Yes	149	50	DBP	88.13	14.30
	No	149	50			
Diabetes mellitus	Yes	90	30.2	HbA1c	8.24	1.96
	No	208	69.8			
Healthy individuals		59	19.76			

HTN: Hypertension, HbA1c: Glycated haemoglobin, DM: Diabetes mellitus

A negative correlation was found between diastolic blood pressure (DBP) and cognition (r = -0.267; p = 0.020) which had a statistically significant difference, indicating that higher DBP causes cognition to deteriorate in hypertensive patients. Despite the findings, the study did not reveal any significant correlation of systolic blood pressure (SBP) with cognition and balance. Hence, it can be inferred that SBP does not influence balance ability nor does it cause cognitive decline. Furthermore, the study did not find any significant association between DBP and balance, implying that DBP does not result in balance issues. However, DBP was found to have a correlation with cognitive deterioration among patients (Table 2).

Table 2.Correlation of Blood Pressures With Balance and Cognition

Associations	Pearson Correlation (r)	p Value
SBP & MoCA	-0.148	0.204
DBP & MoCA	-0.267	0.020*
SBP & BBS	-0.056	0.633
DBP & BBS	-0.099	0.399

*0.05 significant level, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MoCA: Montreal Cognitive Assessment, BBS: Berg Balance Scale

According to the analysis, the mean Berg Balance Scale (BBS) value of the diabetic population was 46.55 ± 11.05 and that of the non-diabetic population was 50.81 ± 9.65 (Table 3). All the participants fell under the low balance impairment category, however, the scores of BBS were lower for diabetic participants than those for non-diabetic participants with a significant difference (p = 0.001) indicating that participants with T2DM showed an effect on balance ability when compared to healthy individuals. Similarly, the mean score of MoCA for the diabetic population was 20.03 ± 5.51 and that of the non-diabetic population was 22.00 ± 6.33, which belonged to the mild cognitive impairment group. The mean MoCA score of diabetic patients was less than that of non-diabetic patients with a statistically significant difference (p = 0.012) indicating that T2DM causes decline. To determine the relationship between balance, cognition, and blood pressure concerning diabetes, the Pearson correlation coefficient test was applied. Among the diabetic group, there was a negative linear relationship between SBP and cognition (r = -0.429; p = 0.041) (Table 4).

Table 3.Comparison of Balance and Cognition Between Diabetics and Non-diabetics

BBS/ MoCA	Diabetes				t Value	p Value
	Yes		No			
	Mean	SD	Mean	SD		
BBS	46.55	11.05	50.81	9.65	-3.33	0.001*
MoCA	20.03	5.51	22	6.33	-2.54	0.012*

*0.05 significant level, MoCA: Montreal Cognitive Assessment, BBS: Berg Balance Scale

Table 4.Relationship of Balance and Cognition with Individuals Having Blood Pressure and Diabetes

Associations	Diabetes	
	Pearson Correlation (r)	p Value
BBS & MoCA	0.082	0.448
SBP & MoCA	-0.429	0.041*
DBP & MoCA	-0.104	0.637
SBP & BBS	0.117	0.593
DBP & BBS	-0.295	0.172

*0.05 significant level, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MoCA: Montreal Cognitive Assessment, BBS: Berg Balance Scale

The association of balance and cognition was done in individuals who suffered from both diabetes and HTN. The statistics showed a "r" value of -0.429 with a p value of 0.041 which suggests that people who suffer from diabetes having altered systolic blood pressure have impaired cognitive functioning. However, diastolic blood pressure did not show any association of cognition with diabetes and HTN. Similarly, balance was assessed using BBS scores. Here, no

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association was found between SBP and BBS (r = 0.117) and between DBP and BBS (r = -0.295). The p values were 0.593 and 0.172 respectively (Table 4).

Discussion

The current study shows an inverse relation between DBP and cognition, but no correlation between DBP and balance or of SBP with balance and cognition. When compared to non-diabetic subjects, T2DM participants had an association with both balance and cognition. Impaired blood pressure i.e., both SBP and DBP, is majorly associated with a disruption in neurovascular blood flow, which leads to a decrease in vascular reserve capacity and can cause microvascular disease. Neurovascular coupling leads to an interaction between neurons, enabling the redistribution of cerebral blood flow to areas of increased activity and metabolic demand.[10,11] According to the pre-existing data, it is intriguing that DBP is independently related to impaired cognition status. Neuropathological data clarifies that the elevated DBP levels accelerate the vascular atrophy process and cause the formation of ischaemic white matter lesions in subcortical areas of the brain. In a longitudinal study, it was noticed that elevated DBP in patients with untreated HTN led to atrophy of structures such as the hippocampus and amygdala which was screened by MRI. Follow-up was done where an MRI was taken after 5 years and the MRI findings showed further atrophy of the amygdala.[12,13] It has been seen that 10 mmHg of increment in DBP leads to 7% higher odds of impaired cognitive status in the Italian population, whereas a 10 mmHg difference gives more than 10% decrement in cognitive status in the Indo-US population. It was also seen that a 10 mmHg increment in DBP leads to about 45% chance of cognitive impairment. According to the results of our study, we can state that cognitive status is altered in the pre-hypertensive stage in older-adult population as suggested in another study.[12]

The p value for DBP and BBS was found to be 0.39 suggesting no relationship between DBP and balance. A comparison with similar findings observed in a study conducted on 47 normotensives and 65 hypertensives revealed comparable outcomes, with no notable variation observed in balance assessment. The study states that various systems are involved in balance control apparatus like somatosensory, visual, vestibular, musculoskeletal and others. These subsystems may be affected by the ageing process which may affect balance and not only hypertension.[14] A prospective study was conducted to examine the links between falls, physical balance, and standing and supine BP in elderly individuals. The result showed that DBP has no effect on balance, as the results established in the present study.[10] However, one study suggests that lower standing SBP, even within normotensive ranges, was an independent predictor of falls in the community-dwelling elderly.[15] Another study suggests that blood pressure was associated with the risk of falls. Hypertensive values decreased the risk in women and low blood pressure increased the risk in men.[16] Above observations suggest that blood pressure plays an important role in balance among the elderly.

A study on the association between SBP and mortality risk with the level of cognitive function was investigated in older adults with a sample size of 1115 participants. Based on the MMSE scores, the study findings suggested that there was no correlation between SBP and cognitive decline. Therefore, it can be concluded that cognitive impairment may or may not be related to blood pressure.[17] The values of SBP in relation to balance impairment and independent living were studied on older adults, and the results concluded that there was no association between the two; similar findings were noted in the current research.[18] Another study reached a similar conclusion that SBP rises progressively with age compared to DBP and that isolated SBP is the most prevalent form of hypertension, which can lead to various diseases. The reason behind this is that SBP plays a crucial role in regulating the heart, brain, and renal function, making it an essential risk predictor for cardiovascular disease, stroke, and end-stage renal disease. Therefore, it is deemed critical to monitor SBP levels to prevent these health complications. The effect of SBP on balance showed no association. A study that compared the effects of blood pressure on falls reported that high SBP was associated with a risk of falls in the elderly.[16] However, given the fact that the population in the study were considerably younger compared to the other subjects in the studies, we can conclude that the subjects in the pre-hypertensive stage may not experience impairment in auto-regulation of BP and would have better arterial and vascular supply compared to the elderly.

Participants with T2DM had low BBS scores and cognition as compared to the non-diabetic population. It was evident that balance in adult people with T2DM was affected when compared to normal elderly. Type 2 diabetes may hasten the natural ageing process in several body systems, resulting in impairments.[19] It was observed in the current study that T2DM patients had lower MoCA scores[19] than non-diabetic subjects, which could be due to a long-term hyperglycaemic state in blood vessels, which could hasten neurodegenerative changes in the brain, thereby leading to cognitive impairment. In a study of 448 older adults, it was found that diabetes was linked to a more rapid decline in MMSE over a span of 9 years. Brain MRI markers of atrophy, including total grey matter, ventricles, hippocampus volumes, and small vessel disease, largely accounted for this effect. In this study, people with both hypertension and diabetes mellitus identified a correlation with their cognition.[11] This means that the combined

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effects of the two disorders might lead to a deterioration in cognition. The results of this study are consistent with previous research, suggesting that subcortical small vessel dysfunction (SSVD) could be the underlying cause of both diseases. Both hypertension and hyperglycaemia have been identified as risk factors for SSVD. DM causes hyperglycaemia and hyperlipidaemia; both are detrimental to the vasculature. This can impair the blood-brain barrier function, lowering glucose uptake in the brain, resulting in silent SSVD and brain shrinkage, thus cognitive deterioration in patients occurs. Furthermore, HTN is also linked to cerebrovascular illness, lacunar brain infarction, and white matter lesions. As a result, when both HTN and DM are present in the same patient, all of these characteristics are strongly linked to cerebral circulation dysregulation, which can act as a substantial risk factor for cognitive impairment.

The limitation of this study was motivating individuals to participate in this study due to time constraints at their end. As we did not keep medication history as a factor, the impact of blood pressure and diabetes-controlling medication could not be recorded.

Conclusion

Hypertension with increased diastolic pressure results in detrimental cognitive decline, which can further act as a catalyst to cause more issues related to cognition. However, SBP and DBP were not found to be correlated to balance. An increase in the glycaemic level likely affects cognitive ability. Hence if hypertension and diabetes are kept under control, it will possibly prevent or delay the occurrence of cognitive and balance compromise.

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