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Original Research Article

Effect of Resistance Training on Improving Cognitive Function in Subjects Having Type 2 Diabetes with Mild Cognitive Impairment

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ABSTRACT

Background: Diabetes mellitus is a metabolic illness that happens whenever blood glucose levels increase. Investigations have proven that Type 2 diabetes is associated with higher risk of cognitive impairment and functional limitations. The extent and severity of cognitive dysfunctions depending upon the duration of diabetes and glycemic control, but it is difficult to do a prediction on who will be at a higher risk for developing cognitive dysfunctions. Cognitive impairment can put up to functional limitations and lead to functionally dependence. Recent researches have shown that cognition and motor performance are interdependent and integration of these two functions are required for the successful performance of daily life activities.

Purpose: To investigate the effects of Resistance training on Cognition in people with type 2 diabetes mellitus having mild cognitive impairments,

Materials and method: Thirty type 2 diabetes mellitus subjects between the age group of 45 -60 years were selected purposively and were randomly divided into two groups, Group A and Group B, with 15 in each group. Group A received resistance training along with conventional physiotherapy for 3 days a week for 4 months. Group B received conventional physiotherapy alone. Montreal Cognitive Assessment scale (MoCA) was used to assess cognition. Pre score was taken before the first session and post score was taken after 4 months, using Montreal cognitive assessment scale (MoCA).

Analysis: Follow up values was taken after four months. The results from outcome measure suggest that Group A ($p<0.05$) has greater effects when compared to Group B. The pre and post values of MoCA was analysed using Paired t-test and Wilcoxon signed rank test for within the group analysis and the between group analysis was done using Mann Whitney U Test. The corresponding p value of less than 0.05 was considered significant for each outcome.

Results: Comparison of Group A and Group B using MoCA score at the end of study in both group was found to statistically significant ($p<0.05$). The Group A shows greater statistical significance when compared with Group B.

Conclusion: The study reveals that the addition of resistance training along with conventional exercises enhances cognitive function in subjects having type 2 diabetes mellitus with mild cognitive impairment.

Keywords: Resistance training/resisted exercise, Mild Cognitive Impairment, Type 2 diabetes mellitus.

BACKGROUND

A common metabolic disease called diabetes mellitus is characterized by hyperglycemia which occurs due to defects in either secreting insulin, or its action or by both.[1] According to World Health Organization (WHO), this is a chronic condition which happens either when the production of insulin is reduced or limited by pancreas or the body cannot utilize the produced insulin by its own.[2] Currently, 49% of world's diabetes issues is represented by India.[3] It was found by a prospective cohort study that the incidence of type 2 diabetes was 21.9% in kerala.[4] On the other hand, the prevalence of cognitive impairment in Type 2 Diabetes Mellitus (T2DM) people in Kerala was seemed to be 54.3%.[5]

Diabetes is connected with cognitive decline and structural changes in brain. Regardless of the type of diabetes whether it is type1 or 2; fifty percentage of the population with diabetes have a greater chance of emerging cognitive dysfunctions and dementia with attention impairment, understanding of information and motor act speed, mental skills, and verbal memory.[6] As per the studies, these cognitive impairment has been shown by both types of diabetes, type 1 and 2.[7] However, people with T2DM have much more cognitive decrements than type 1 and they show reduced executive function, memory, learning, attention and even psychomotor efficiency.[8,9,10]

Fluctuations in blood glucose levels may be stressful in patients with T2DM and cause rapid mood changes and other mental symptoms such as fatigue, trouble thinking clearly, and anxiety. Type 2 diabetes can lead to a clinical condition called diabetes distress, sharing the features of stressfulness, depression, and anxiety, and can also be affected by external factors**,** family and social supports, and health care services. These psychological stresses found to be a reason for cognitive dysfunctions in Type 2 Diabetes mellitus.[11]

Long-term hyperglycemia has been documented to result in complications of mitochondrial dysfunction, accumulation of plaque (amyloid precursor protein), and oxidative and pro-inflammatory stress on brain tissue.[12] Diabetes-related neuro-degeneration has been associated with increased risk for developing Alzheimer disease and vascular dementia and, subsequently, significant cognitive declines.[12, 13] Specifically, brain imaging studies have demonstrated diabetes-related declines in executive function were associated with cortical (prefrontal) and subcortical abnormities.[14, 15] Furthermore, poor glycemic control (glycated hemoglobin levels >7.0%) has been associated with a 4-fold increase in mild cognitive impairment in older adults with type 2 diabetes (32).[16]

A sedentary lifestyle and unhealthy food habits have increased the chance of distinct lifestyle diseases, which include diabetes. A three-fold increase in the risk of diabetes occurs due to the lack of physical activity. Lack of proper exercise also increases the chance of cardiovascular diseases by 2.4 folds in Diabetes patients. Diabetes reduces the capacity to exercise mainly because of obesity, physical inactivity, sedentary lifestyle, impaired joint functions, and complications due to diabetes including heart disease, peripheral neuropathies, and neuropathic foot diseases due to diabetes mellitus.[17]

Isolated studies have identified adults with type 2 diabetes without overt complications of DPN to also be at increased fall risk. It is known that the ability to maintain balance is a complex skill that requires the integration of cognitive processes and multiple sensorimotor.[18] Older adults with type 2 diabetes have been documented to adopt cautious strategies to maintain balance during dual-task walking, possibly to compensate for limited processing capacity (or cognitive resources) to divide between tasks; this may possibly be linked to reduced cerebral vaso-reactivity (e.g. reduced capacity to regulate cerebral blood flow in response to greater metabolic demands) in older adults with type 2 diabetes.[18, 19]

Many studies were conducted to evaluate the efficacy of exercise on quality of life, but the results were contrasting. Myers et al. did a study comparing the effect of aerobic, resisted exercise, and a combination of aerobic resisted exercise on the standard of living among diabetic patients. The study showed that all these exercises and the combination of both improved the physical quality of life.[20]

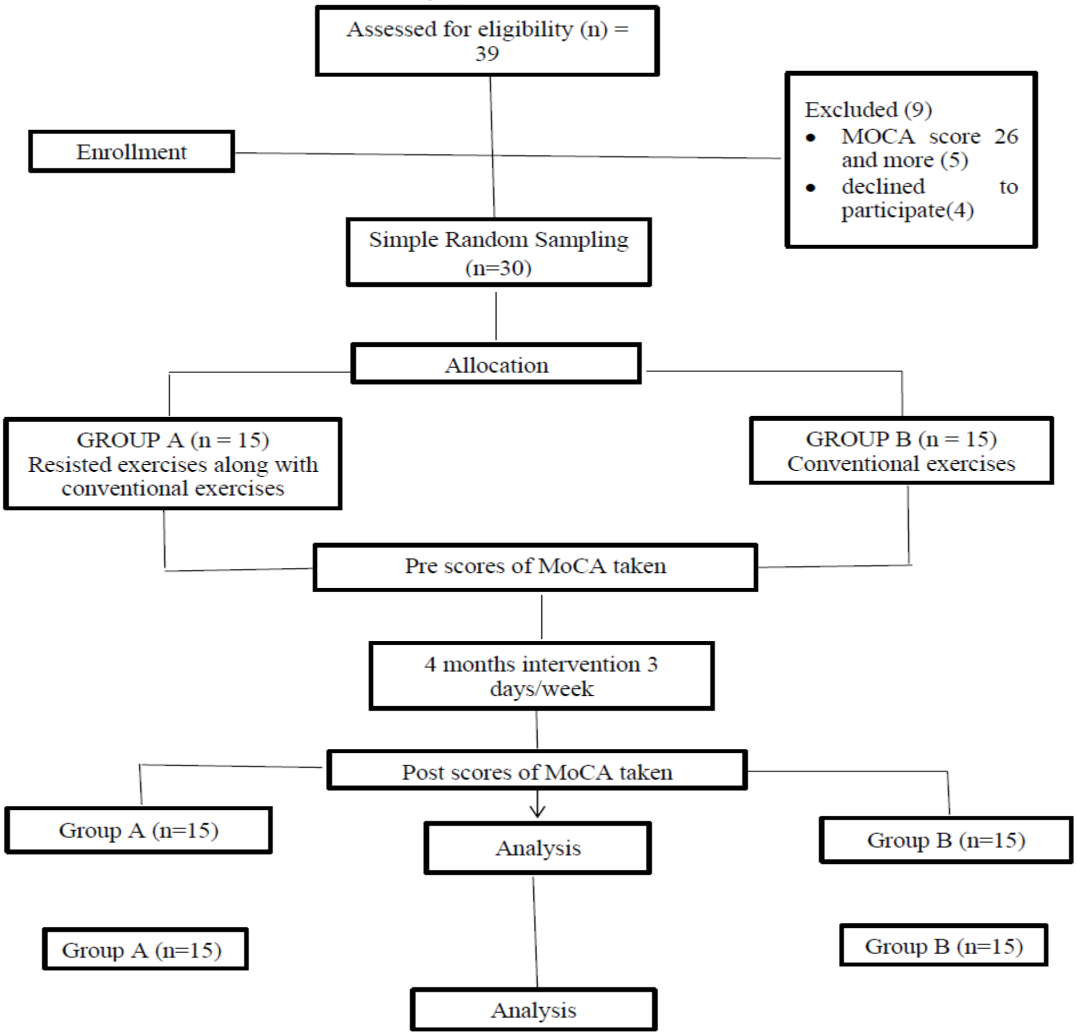
But there is paucity of literatures in the field of diabetes that explains the effect of resisted exercises in improving the cognitive functions which has an urgent need in the society, in the background of increased prevalence of diabetes mellitus and associated cognitive dysfunctions. The research also showed that diabetes was efficiently controlled by exercises when compared to any physical modality (Myers et al., 2013).[20] Based upon the reported findings, the primary objective of this study is to investigate whether Resisted exercises will improve the cognitive functions in Type 2 Diabetes mellitus. This study will also add to the knowledge of physiotherapy by concentrating on the physical activity to enhance Cognitive functions in Type 2 Diabetes mellitus.

MATERIALS AND METHODS

PARTICIPANTS: A total of 30 subjects clinically diagnosed with Type 2 Diabetes mellitus subjects, who fulfilled the inclusion criteria were randomly assigned into two groups. Subjects were recruited from Department of Diabetology and Physiotherapy, Little Flower Hospital and Research Centre, Angamaly. Ethical clearance was obtained from the Institutional Review Board and Ethical Committee of the institution 30 subjects who fulfilled the inclusion criteria were randomly assigned into two groups: 15 in group A and 15 in group B. Written informed consent was obtained from the subjects. Subjects in Group A received resisted exercises along with conventional exercises, whereas subjects in Group B received conventional exercises alone. All subjects met the following inclusion criteria: (1) subjects having T2DM =/> 5 years,(2) Montreal Cognitive Assessment score between 18 to 25, and (3)the subjects having presence or absence of co-morbidities such as hypertension and dyslipidemia. Subjects were excluded with following exclusion criteria: (1) Subjects those who are medically unstable, or(2) under other routine physical exercises, (3) with type 1 DM, (4)dementia, (5) diabetic neuropathy, nephropathy, retinopathy, (6) diabetic ulcers, (7)subjects with autonomic instability,(8) pain and inflammation (9)degenerating and demyelinating diseases of CNS, (10)vestibular dysfunction, (11)chronic respiratory conditions (12)with degenerative and inflammatory musculoskeletal disorders, (13)malignancy, recent fractures and surgeries, spinal deformities (14) psychiatric and non-cooperative, were excluded from the study. Subjects were required to sign a written informed consent document approved by the ethical committee at Little Flower Hospital and Research Centre, Angamaly.

STUDY DESIGN: This study was an RCT, pretest -posttest experimental design taking place during study period. Thirty subjects were randomly allocated into two groups by the investigator who was involved in data collection, treatment implication, and data analysis. A total of 39 subjects clinically diagnosed with Type 2 Diabetes mellitus subjects were assessed for eligibility and 30 subjects who fulfilled the inclusion criteria were randomly assigned into two groups. Subjects in group A (experimental group) received resistance training along with conventional physiotherapy treatment, while subjects in group B (control group) received conventional physiotherapy. Both the groups received this protocol for a period of four months, with a frequency of 3 times in a week. Baseline assessments were done after randomization, at the start of the protocol and at the last day of treatment. For each subject, all assessment sessions were performed at the same time of day, to control for variations in performance due to climatic variations.

Fig (1) Consort Flow chart



REHABILITATION PROGRAM:

The rehabilitation program consists of 3 sets of 10 repetitions per session for four months**.** Intervention was conducted individually and not in a group format. The physical therapist was involved in performing the intervention as well as conducting the assessments. All treatment sessions occurred at the same time of day on the same 3 days of the week throughout the study.

Subjects in experimental group received resisted exercises along with conventional exercises which includes warm up and cool down phase. The warm up session were given for subjects before every session for duration of 10 minutes, which includes, slow-paced walking and active mobility exercises for the joints of the four limbs. The resistance training adopted for the study was Circuit training exercise regime (40 minutes) with progressive high intensity protocol in a sequential order of (1) Biceps curls (2) Triceps extensions (3) Hamstring curls (4) Quadriceps extension (5) Calf raises by using free weights (weight cuffs and dumbbells). Initially subject is asked to perform the resistance exercises at an intensity of 60%-70% of one repetition maximum for 3 sets of 10 repetitions. A 30 second break is given in between the sets and after each exercise one minute rest is given. As each subject's strength of muscle increased, the given weight is then increased up to their maximum of 75%-80% of 1-RM. Conventional therapy was given to both groups for a duration of 15 minutes which consisted of (A) Stretching/flexibility exercises: 2-4 repetitions with 10 second hold for each muscle (Biceps, Triceps, Hamstring, Quadriceps, Calf muscle). (B) Balance/ tone exercises (Standing on one foot for any duration, Walk on heels and toes, Walk backwards and sideways, and Sit to stand for 10 times each.[21] All sessions are ended up with cool down exercises, which took 10 min to complete, and that includes Relaxation technique like controlled breathing and *Savasana* yoga.

RESULTS

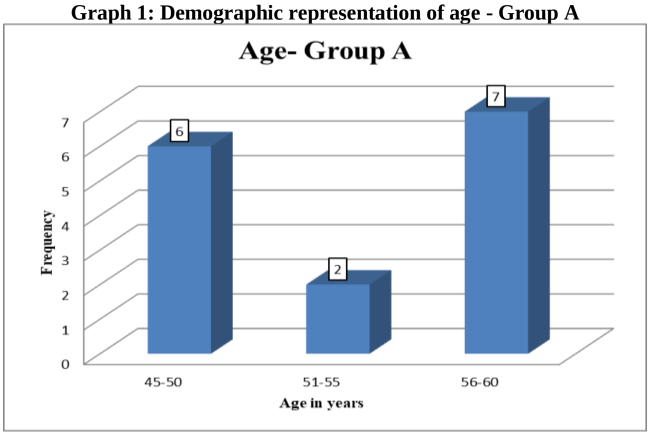
The obtained data was analysed using SPSS Version 20.00. Baseline homogeneity was established using Shapiro-Wilk test as the sample size was 30. The pre and post values of MOCA were analysed using Paired t-test and Wilcoxon signed rank test for within the group analysis. And as the outcome variable MOCA was not normally distributed, the between group analysis was done using Mann Whitney U Test. Since the calculated values are greater than the table value, there is statistically significant improvements in MOCA scores in both groups ($p<0.05$). Since, all the obtained values were greater than the table value, there is statistically significant difference between group A and group B ($p<0.05$). Group A showed more e statistically significant improvement in MOCA compared to group B.

Thus, from the obtained results, it can be inferred that, there is significant effect on resisted exercise along with conventional exercise in improving cognitive function when compared to conventional exercise alone, in subjects having type 2 diabetes with cognitive impairment.

Table 1: Demographic representation of age

GROUP	MEAN	SD
GROUP A	53.6	±4.79
GROUP B	53.6	±4.6

Graph 1: Demographic representation of age - Group A



Graph 2: Demographic representation of age - Group B

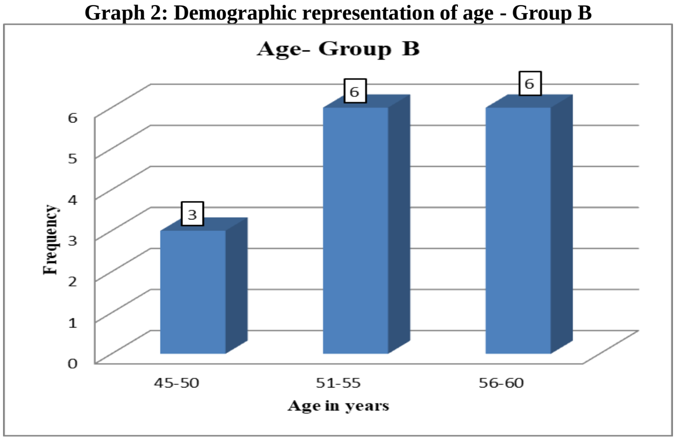
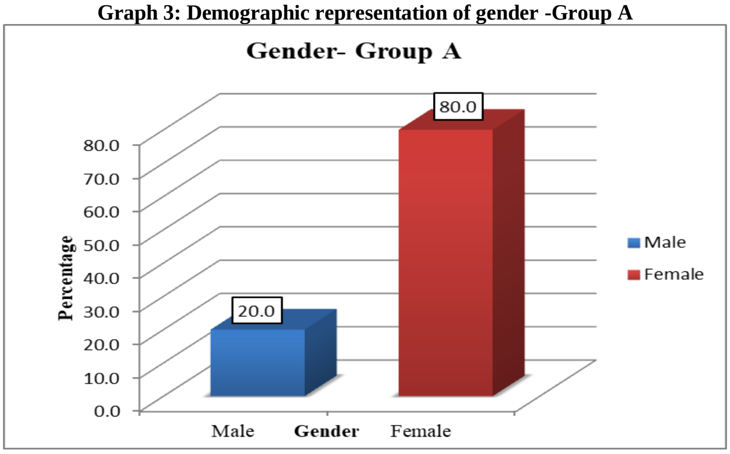


Table 2: Demographic presentation of gender

GENDER	GROUP A		GROUP B	
	Frequency	Percentage	Frequency	Percentage
MALE	3	20.0	7	46.7
FEMALE	12	80.0	8	53.3

Graph 3: Demographic representation of gender -Group A



Graph 4: Demographic representation of gender -Group B

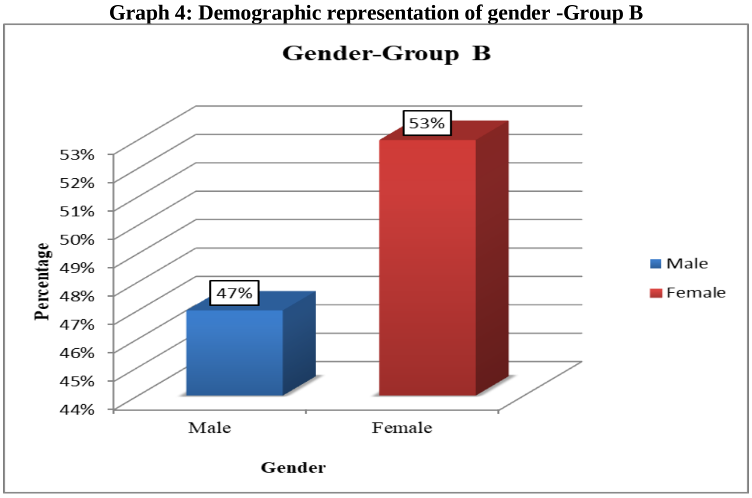
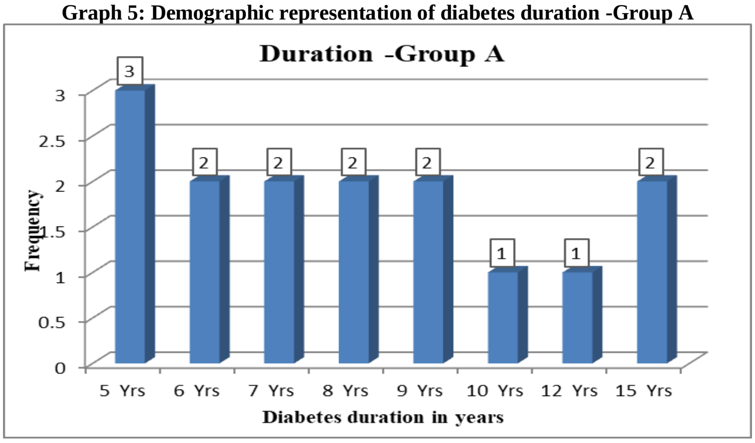


Table 3: Demographic representation of diabetes duration

Diabetes duration	MEAN	SD
GROUP A	8.47	±3.31
GROUP B	8.13	±4.015

Graph 5: Demographic representation of diabetes duration -Group A



Graph 6: Demographic representation of diabetes duration -Group B

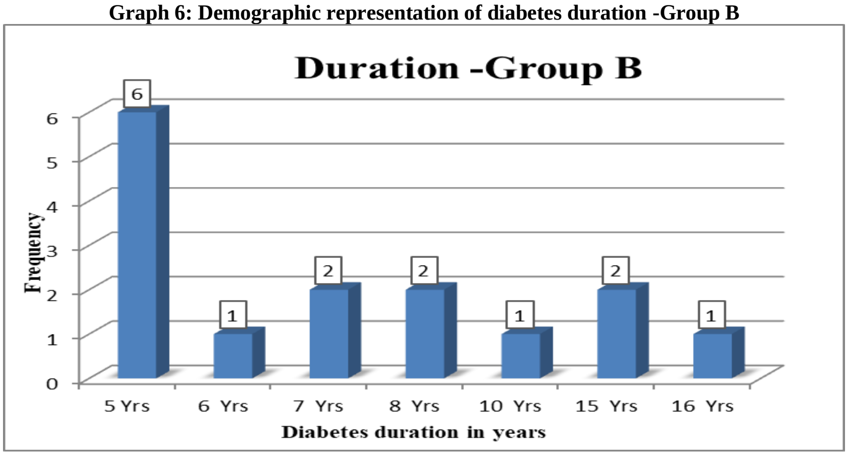
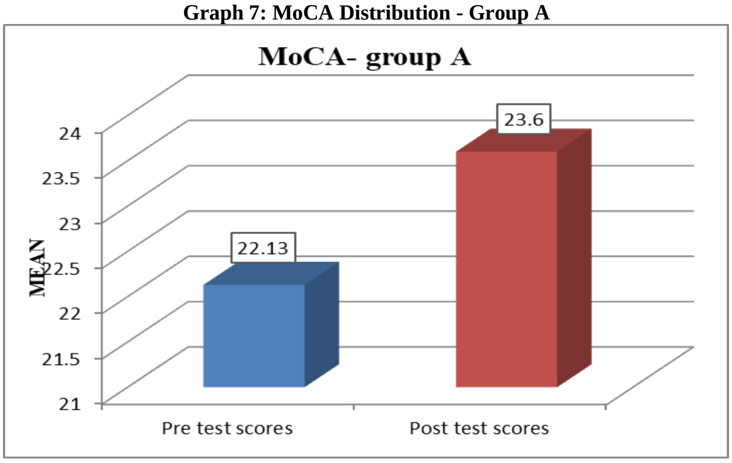


Table 4: Statistical results- within group comparison MOCA

GROUP	Pre-test scores	Post-test scores	Mean deviation	t Value	z Value	p Value
Group A	22.13±2.26	23.6±2.29	1.47±0.516	11.00		0.000
Group B	22.40±1.76	23.47±1.84	1.07±0.258		3.77	0.000

Graph 7: MoCA Distribution - Group A



Graph 8: MoCA Distribution - Group B

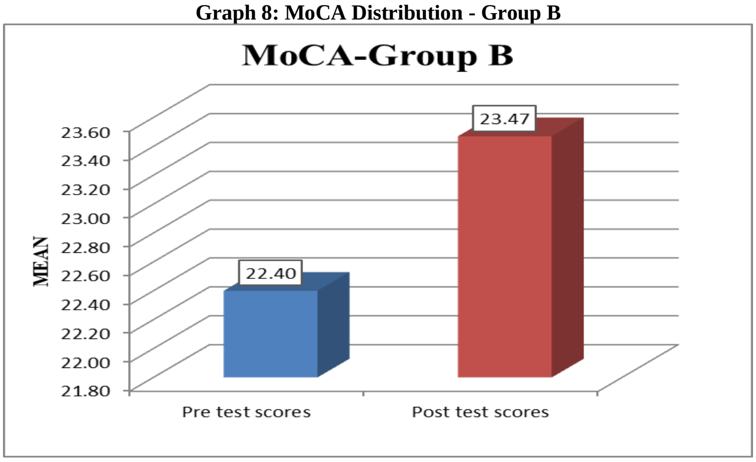
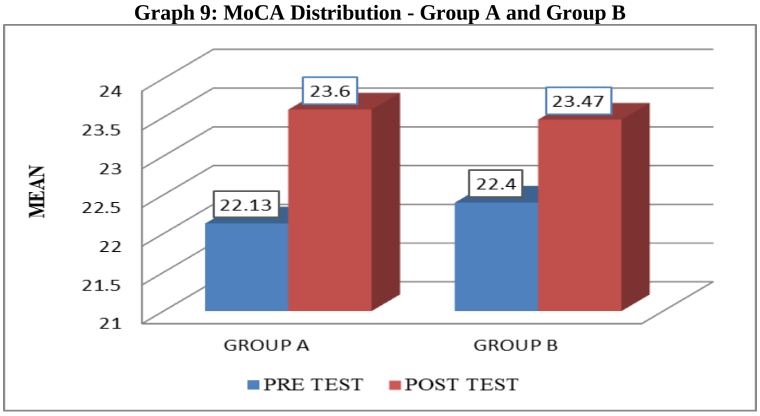


Table 5: statistical results- between group analysis

MOCA	N	Mean difference	Standard deviation	z Value	p Value
Group A	15	1.47	0.516	2.436	0.015
Group B	15	1.07	0.258		

Mann Whitney U test, P<0.05 considered as statistically significant

Graph 9: MoCA Distribution - Group A and Group B



DISCUSSION

30 diagnosed cases of type 2 diabetes of duration more than 5 years with cognitive impairment who met the inclusion criteria were divided into two groups of 15 each, Group A and Group B. Group A received resisted exercises along with conventional exercise and Group B received conventional exercise alone. The total duration of the intervention was 4 months. The outcome measure used was MoCA. Assessments were taken on the first day before and the last day after the treatment. At the beginning, both groups received warm up exercises and at the end both received cool down exercises. The results showed a significant improvement in cognitive performance in both groups. Even though both groups showed improvement, Group A showed more statistically significant improvement in MoCA compared to group B.

In a study which is conducted by L.S Nagamatsu et al in 2012, it is proved that for older people those who have mild cognitive impairment, the resisted exercises is an encouraging plan to alter the decline.[22] It can be due to several possible mechanisms. The study put forwarded by Shaikh MK in 2012 reports that there is elevated amount of plasma homocysteine in people with T2DM.[23] This can higher the possibility for cardiovascular events, cerebral artery stenosis and cognitive dysfunction.[24, 25] However in 2003, Vincent KR stated that resisted exercise influenced in reducing the level of homocysteine in diabetes people.[26] So this might be one of the contributing factors for improving cognition.

There are several studies reporting that the molecular factors like insulin like growth factor (IGF-1) and brain derived neurotrophic factor (BDNF) are reduced in diabetes patients when compared with normal healthy adults.[27] These factors are more evident in functional areas of central nervous system which is associated with cognition. A study performed by Cassilhas R.C et al promises that the resisted exercise could elevate the amounts of these above mentioned factors thereby enhances synaptic plasticity and survival of neurons, improves formation of new blood vessels and also the growth and development of new neural tissues. These changes can alternatively improve cognitive performance and might be one of the another mechanisms behind .[28-31]

There are supporting literatures suggesting that the amount of muscle strength which is achieved by the resistance training has a connection with brain health and functioning. Reports claims that higher levels of strength of the quadriceps muscle are linked to better performance in general cognitive function and better executive functions.[32-34] As we trained our subjects with quadriceps extension exercise, this can be another factor which led improved cognition. According to Suo C.et al in 2016, resistance training increases the functional connectivity among posterior cingulate cortex, the left inferior temporal lobe, and the anterior cingulate cortex and between the hippocampus and the right middle frontal lobe.[35] Thus, we can infer that, this mechanism can be another contributing factor for enhancing cognition.

Additionally, a plethora of literatures supports that the resistance exercise produces tremendous changes in the biological mediators of anxiety. Resistance training following both short-term and long-term training has been linked to anxiolytic effects in human populations, according to a growing body of data.[36,37] To sum up, the above mentioned possibilities could helped these subjects in improving cognition.

Hence the study concludes that, the effect of resisted exercise has an important role in improving cognitive function in subjects with type 2 diabetes with cognitive impairment. The present study had limitations of small sample size, short duration of intervention and no follow up after the study. Also the pre-post glycaemic value was not assessed. Future studies which address these limitations should be conducted.

CONCLUSION

The finding of this study supports our main hypothesis that resistance training along with conventional therapy is more effective on improving cognitive functions of diabetic patients with mild cognitive impairments. Hence, the study reveals that, addition of resisted exercises to conventional rehabilitation components enhances faster recovery in subjects having type 2 diabetes with cognitive impairment, as warranted.

List Of Abbreviations

DM: Diabetes Mellitus
MCI: Mild Cognitive Impairment
MOCA: Montreal Cognitive Assessment
T1DM: Type 1 Diabetes Mellitus
T2DM: Type 2 Diabetes Mellitus
WHO: World Health Organisation

AUTHOR'S CONTRIBUTIONS: The author's confirm contribution to the paper as follows: study conception and design: Beesmol Babu and Manju Unnikrishnan; Data Collection: Beesmol Babu; Analysis and Interpretation; Remya N, Chinchu Alwin and Rejimol Jos Pulicken; Draft manuscript: Beesmol Babu, Manju Unnikrishnan, Reethu Elsa Baby. All the authors reviewed the results and approved the final version of the manuscript.

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Ethical Approval: Approved

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