ISSN: 2394 - 2053 (Print)
ISSN: 2394 - 2061 (Online)
RN: ASSENG/2016/70661
www.ojpas.com

ORIGINAL RESEARCH PAPER

Open Journal of Psychiatry & Allied Sciences

Cognitive dysfunction in urban elderly people: an exploratory study using neuropsychological and neuroimaging perspective

Abstract

Background: Cognitive impairment is an integral part of old age as well as it is a part of many neurodegenerative disorders. Early identification of cognitive impairment is necessary in order to make treatment and rehabilitation possible. **Materials and methods:** Keeping in mind that early identification of cognitive impairment is necessary, a sample of 20 elderly patients with memory complaints who were referred for magnetic resonance imaging (MRI) with symptoms of peripheral nervous system disorder by neurologists have been assessed using neuropsychological tests and MRI, and results have been analysed using IBM SPSS 21 and DICOM software. **Results:** Neuropsychological test findings suggest that age, sex, and education are related to performance of the participants on different tests of cognitive functions in different ways. Scores on the tests of delayed memory and verbal fluency emerged as positive predictors of activity level. On the basis of MRI, the elderly people were identified with periventricular hyper-intensity of white matter and global cortical atrophy. A comparison of the two groups (on the basis of MRI findings) suggest that elderly people with global cortical atrophy were found to be significantly more impaired on visuospatial tasks in comparison to the group with periventricular hyper-intensity of white matter, among other tests of cognitive functions. **Conclusion:** In spite of the absence of manifestation of dementing illness at clinical level, the participants actually exhibited underlying pathological process which can be detected with neuropsychological testing in conjunction with neuroimaging.

Keywords: Old Age. Neurodegenerative Diseases. Cognitive Impairment. Magnetic Resonance Imaging.

Sreerupa Ghose[1], Sanjukta Das[2], Anup Sadhu[3]

[1]Research Scholar, Department of Psychology, University of Calcutta, 92, APC Road, Kolkata, West Bengal, India, [2]Professor, Department of Psychology, University of Calcutta, 92, APC Road, Kolkata, West Bengal, India, [3]Consultant Radiologist, Eko CT and MRI Scan Centre, Medical College Campus, Kolkata, West Bengal, India

Correspondence: Sanjukta Das,
92, APC Road, Kolkata-700009, India.
sanjuktahope@gmail.com

Received: 16 November 2016
Revised: 8 February 2017
Accepted: 28 March 2017
Epub: 9 May 2017

DOI: 10.5958/2394-2061.2017.00011.8

Introduction

With immense advancement in medical science, there is a sharp rise in longevity and a following rise in the percentage of elderly population worldwide. Cognitive functioning of the elderly show natural decline even when no significant diagnosable brain dysfunction can be detected. Since ageing of brain does not go parallel with the chronological age and shows considerable individual difference, the geriatric population, in terms of brain functioning, is very heterogeneous. However, degeneration and cognitive impairment (CI) is an integral part of normal ageing process but the line between CI in normal ageing and CI in the beginning of any dementing illness is blurred. Often CI is not identified until it has considerably progressed and in most cases it is too late for any treatment and rehabilitation. Recent advances in neuroimaging techniques like magnetic resonance imaging (MRI) and functional MRI (fMRI) provide considerable precision in differentiating the characteristic features of severity of decline in brain functions based on the identification of distribution of brain activation and structural changes.

With this view, the present study is conducted on a group of non-institutionalised elderly people who have reported to have some memory complaints by their family members but has no current diagnosis of any psychiatric illness or any degenerative disorder. The study is analysed in two sections. The objective of the Study 1 purports to investigate the relationship of socio-demographic variables (age, sex, and education) with different domains of cognitive functioning; it also purports to find out the contributory effects of different domains of cognitive functions on activity level. The objective of the Study 2 is to find out the nature of structural changes of brain in those patients using neuroimaging technique. Lastly, it aims to compare the neuroimaging profiles of the patients with respect to activity level and different domains of neuropsychological functioning (as found in Study 1).

Materials and methods

The present study was conducted in a neuroimaging unit (Eko Diagnostics) of Calcutta Medical College and Hospital of Kolkata. It was conducted between January 2016 and March 2016. The study plan was passed by the board of

experts of the Central Ethical Committee of University of Calcutta and all the standard ethical principles have been complied with. It is envisioned as a pilot study of a larger research work. The present sample consisted of community living (non-institutionalised) elderly people who were referred for MRI with symptoms of peripheral nervous system disorder by neurologists. Verbal consent was taken from the patients and their accompanying family members; data was taken from only those patients who consented willingly to participate. They belonged to an age group of 50 to 75 years and were reported to have no prior diagnosis of dementia, mental retardation, or any DSM-IV Axis I disorder. They were right handed with at least two years of education and were corrected for vision and audition. Individuals presently diagnosed with functional (psychiatric) disorders and/or mental retardation were excluded on the basis of mental status examination or case history. Patients having history of meningitis or encephalitis, any psychiatric disorder, any pre-existing nervous system problem, hypothyroidism and other metabolic disorders, active substance abuse, any difficulty with arm movement were also excluded from the study. The sample was selected using purposive method of sampling.

Elderly patients who were reported to have some memory complaints by self or family member were approached. Data were collected from those who consented to take part in the study. Brief case history and mental status examination were conducted before neuropsychological assessment was done. Neuropsychological assessment was followed by MRI. Neuropsychological functioning was assessed using Kolkata Cognitive Screening Battery (KCSB),[1] developed and standardised on community living elderly population of Kolkata. KCSB was initially developed by Ganguly *et al*.[2] as a Hindi version of Mini Mental Status Examination (MMSE) on illiterate rural elderly population and was validated by SK Das on urban Hindi and Bengali speaking people of Kolkata as KCSB. Intra- and inter-rater reliability of the subtests ranged between 0.77 and 0.99. The final version of KCSB consists of eight subtests, viz. verbal fluency tests (category fluency), 15-item object naming test, mental state examination (focusing on orientation principally), calculation test (a single arithmetical problem that requires serial subtraction), word list memory task (a list of ten common words repeated over three learning trials in different orders), visuo-constructional ability (copying of simple geometrical shapes), delayed recall (recalling of words from previously learned list without any cue), and delayed recognition word task (requires the ability to identify the previously learned words from a list of 30 words presented auditorily). Katz Activities of Daily Living (ADL) Index was used to assess ADL in the present sample.[3] Structural images of brain were obtained using MRI technique. On the basis of MRI, cases of normative age related brain atrophy were rejected and ultimately 20 data (male=n1=ten; female=n2=ten) was used for final analysis.

Statistical analysis

In Study 1, the data relating to neuropsychological assessment and activity level were analysed using statistical software IBM SPSS 21.The relationship of socio-demographic variables with different domains of cognitive functioning were assessed using bivariate correlation. Pearson's coefficient of product moment correlation was used to analyse the nature of relation between years of formal education and age with different domains of cognitive functioning while point biserial correlation was used to find the nature of relationship between sex and cognitive domains. Stepwise multiple regression was used to find the contributory effect of different domains of cognitive functions on level of activity.

In Study 2, MRI images were obtained using a machine of 1.5 Tesla. T1 and T2 images of slice (4 mm) were assessed clinically by experienced radiologist for presence of structural pathology using DICOM software.

Lastly, the functioning of the patients with different types of structural pathology was compared with respect to different domains of cognition using Mann Whitney U test.

The data obtained was analysed at 0.05 and 0.01 level of significance.

Results

The findings from Study 1 suggests that age was negatively related to delayed memory ($r=-0.513$, $p<0.05$) while education was found to be related positively to visuo-constructional ability ($r=0.628$, $p<0.01$) in the same. Calculation subtest performance was found to share a positive relation with sex, with male participants performing better than the female participants. Performance of the patients on the tests of delayed memory and verbal fluency emerged as positive predictors of activity level. In Study 2, ten cases with periventricular hyper-intensities of white matter (Group 1) and ten cases with global cortical atrophy (Group 2) were identified on the basis of qualitative analysis of MRI slides. All 20 cases presented with moderate to severe level of pathology. The group with periventricular hyper-intensity of white matter (Group 1) was found to outperform the group with global cortical atrophy (Group 2) on test of visuospatial functioning ($U=0.019$, $p<0.05$).

Discussion

Difficulty in differentiating normative age related changes from that of non-normative changes has already been documented in literature[4] and contextually raises question about early detection of dementing process in community living aged population. Again as memory complaints are accepted as stereotypical feature of old age, they are often given minimal or no importance by aged people themselves and society in early phases. Hence, often cognitive impairments reach a stage when dementing illness has progressed to a stage where restricting the degenerative process is not feasible. Keeping this in mind an attempt to detect the presence of any neuro-pathological brain features and impairment of cognition in community living elderly patients (above age of 50 years) who have started experiencing some memory difficulties is made in the present study using neuropsychological tests and MRI.

Findings of Study 1 suggests that age was found to be negatively related to delayed memory indicating an increase in chronological age is related to worse performance on delayed memory tasks in spite of preserved sensory functions. In line with existing literature this finding suggests that

cognitive functioning declines with age[4,5] and is typically attributed to neuronal loss with advancing age resulting in brain shrinkage. In the present study, the delayed memory task required remembering list of words for three learning trials and reproducing them after a short delay. Studies report that with advanced age memory declines due to multiple factors. In advanced age, fronto-straital atrophy, white matter changes, and depletion of neurotransmitter may lead to memory difficulties on tasks that demand high level of attention and controlled processing. Age related changes in the anterior brain regions lead to decline in executive function, and controlled and strategic processes that are important for encoding and retrieval of information are impaired.[6] Disturbance in long term declarative memory may result from atrophy of medial temporal lobe structures,[7] as is found in Alzheimer's disease where patients find it difficult to learn a list of words.[8] The relatively better performance of the patients on the recognition tasks in comparison to the delayed memory tasks in the present study indicates decidedly poor free recall in comparison to the ability to successfully discriminate the target words from the distracters during the recognition trial; this suggests the patients' increased difficulty in the ability to use appropriate retrieval strategies showing greater deficit in retrieval than encoding and consolidation which may indicate a decline in function of the fronto-straital circuits.

Positive relation of visuo-constructional ability to years of education indicates that an increase in the number of years of education was related to better performance on tasks of visuo-constructional ability. Other studies have found that lower level education is related to rapid cognitive decline.[9,10] Along with other domains, poor performance on visuo-constructional tasks was found in a study of elderly people in Rajasthan.[11] In a study done on a sample of Korean healthy elderly people over 65 years of age, it was found that literacy had a considerable impact on visuo-constructional ability with the uneducated-illiterate group emerging as the worst performer on test of visuo-constructional ability while educated-literate individuals obtained the highest scores.[12] In a study on patients with non-demented idiopathic Parkinsonism conducted in the city of Kolkata using KCSB, it was found that patients with lower education had greater impairment in visuo-constructional ability among other functions.[5] This relation between education and performance of visuo-constructional ability may be due to several factors. One of the principal reasons behind this association could be the protective role played by education by constituting a cognitive reserve which delay expressions of cognitive decline by maintaining global cognitive efficiency.[13] The principal idea behind the concept of cognitive reserve is that cognitive performance across different people cannot be fully explained by factors associated with brain deterioration[14,15] and other compensatory factors (e.g. education, intelligence) mitigate cognitive decline.[6] Training of reading and writing not only develops language functions but also helps to build the ability to use and interpret graphic symbols as education has been found to improve the analysis and organisation of visuospatial information.[16]

Performance on calculation subtest was found to be significantly and positively related to sex suggesting that male elderly people performed better on tasks of calculation in comparison to female elderly people. This subtest consists of a simple arithmetical problem that requires simple serial subtraction and hence requires simple computational ability, knowledge about numerical operation, working memory along with language comprehension and attentional process. In spite of the fact that the male and female individuals in the sample do not differ with respect to age and education, male participants were found to do better on calculating ability which may be the outcome of the lifelong role and occupational differences between male and female in the population under study (as all the male participants were bread earners while female participants were homemakers for whole of their life). The existing literature in this regard shows that studies have found males outperform females on visuo-spatial tasks and arithmetical ability.[17] Gender differences were found in the performance of computation of arithmetical reasoning and use of numerical operations. After controlling for age variation, visuospatial test was found to significantly mediate the effect of sex, with males outperforming the females.[17] As far as the role of neuroanatomical substrates are concerned posterior parietal cortex and prefrontal cortex have been implicated in the arithmetical tasks, in addition to involvement of other brain regions, i.e. caudate nucleus and the cerebellum, with increasing task difficulty. Some researchers[18] found significant gender differences in male and female subjects with respect to structural and functional organisation of right parietal lobe. Greater activation of dorsal (right intraparietal sulcus and right angular gyrus) and ventral (right parahippocampal and right lingual gyrus) visuospatial streams were found in males while female participants were found to have greater grey matter density in these regions. Other studies have found larger inferior parietal lobules (which is significantly implicated in mathematical ability) in males.[19,20] Sowell *et al.*[21] found prominent enlargement in frontal and occipital regions of brain in males and may be this is the reason why males are better in mathematical and spatial abilities.[22]

In the present study verbal fluency has emerged as a predictor of ADL (Figure 1). Among other subtests, verbal

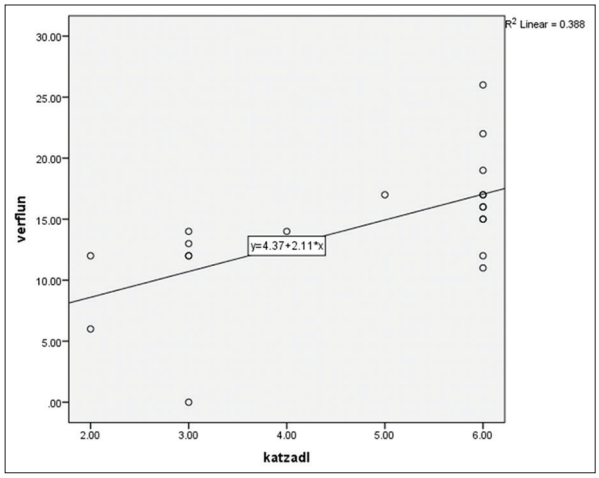

Figure 1: Graph showing contributory effect of verbal fluency on Katz Activities of Daily Living (ADL) Index (activity level). Verbal fluency: verflun, Katz ADL Index: katzadl.

fluency test in KCSB is a test of categorical fluency which is a measure of executive functioning among other functions and requires generation of items of a specific category within specific time. ADL tasks consist of basic self-care activities. The present finding is supported by other studies which have shown that poorer cognitive functioning is related to functional decline in elderly with dementia.[23] Razani *et al*.[23] found that planning, organisation, and maintaining and shifting set were important in carrying out routine daily activities. Studies have found executive functioning to be associated with ADL and instrumental ADL.[24,25] Cahn-Weiner *et al*.[24] found that several aspects of frontal and executive functioning are related to instrumental ADL which is more demanding than the basic ADLs in the community living elderly people. But as basic ADLs also require the ability to carry out several brief tasks in sequential manner in order to bring about the successful completion of an activity (e.g. bathing), some amount of executive functioning is essentially required and this may explain the finding from the present study where verbal fluency has emerged as a predictor of basic ADLs. As far as the neural substrate of executive functioning is concerned, categorical fluency test has been found to be associated with left medial temporal lobe functioning,[26] in contrast to letter fluency test which appears to involve more of frontal lobe functions. In recent years, functional imaging studies are reported to demonstrate that apart from frontal lobes, many posterior areas, especially parietal areas play important role in executive functioning.[27] A vast network including frontal, temporal, and parietal lobes are found to be implicated in verbal fluency test.[28,29] Apart from the executive functioning, fluency tasks are used to measure retrieval from remote memory as fluency tasks require the individual to make strategic search through memory for some 'word' and thus require frontal lobe functioning.

In the present study, delayed memory task has also emerged as a predictor of ADL (Figure 2). Delayed memory task in KCSB involves learning, retaining, and retrieving some information over a period of time, and role of both frontal lobe and medial temporal lobe have been implicated in the process.[30] It is a test of declarative memory and declarative memory relies on hippocampus for encoding of stimuli while for retention it depends on dorsolateral prefrontal areas. The role of memory in performance of ADL is important as memory is essential for the execution of complex abilities;[31] ADL consists of sequential tasks which require multiple steps to be conducted in order to be completed successfully. So the ADL tasks, though practiced over time, require the ability to retain the information of the steps executed previously to reach to the end step as well as to retrieve required information at the time of the performance of the activities. Though procedural memory may be important in performance of the activities and as procedural memories remain unaffected until in later phases of the dementing illness, it is seen that in the present sample of community living elderly people (without diagnosis of any dementing illness) declarative memory plays a more crucial role in performance of the activities of daily living.

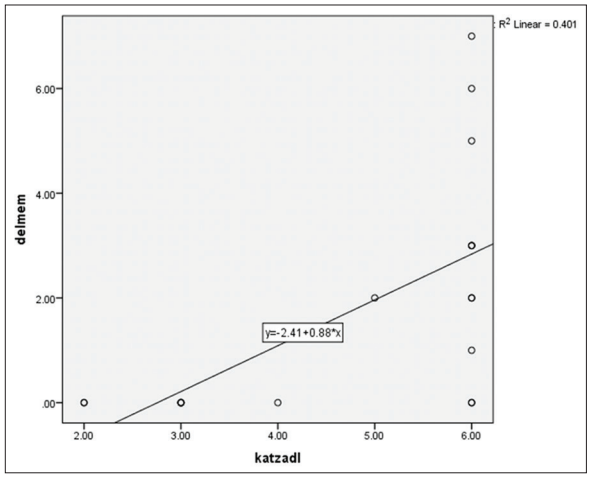

Figure 2: Graph showing contributory effect of delayed memory on Katz Activities of Daily Living (ADL) Index (activity level). Delayed memory: delmel, Katz ADL Index: katzadl.

In Study 2, a clinical analysis of MRI by radiologist reveals principally two types of structural impairments which cannot be explained by age associated brain changes. They are periventricular hyper-intensity of white matter and global cortical atrophy. This finding is supported by existing literature. From the scanning of the existing literature, it is evident that ageing process is random and ageing does not occur at a particular rate or sequence, and hence the type of structural changes and their magnitudes vary across individuals.[32] The steadiest findings in literature show that ageing is associated with brain cell loss resulting in brain shrinkage, increase in ventricular spaces and cerebrospinal fluid. With rise in use of neuroimaging techniques for various clinical purposes, it is becoming evident that both white matter and grey matter brain lesions are prevalent in aged population. Other studies show that the prevalence of white matter hyper-intensities in the general population ranges from 11-21% in adults aged about 64 years to 94% at age 82 years. This includes both deep white matter hyper-intensities and periventricular hyper-intensity of white matter. Systematic studies on cortical atrophy report that ageing brain loses volume in a nonlinear and region-based manner, with prefrontal cortical volume declining more rapidly than other parts of brain. It is found that rates of global atrophy in healthy elderly people increase gradually with age from an annual rate of 0.2% at age 30-50 years to 0.3-0.5% at age 70-80 years in longitudinal studies using high resolution MRI. But, both cortical atrophy and periventricular white matter lesions are also found in dementing illnesses; the most prevalent of cortical dementias being Alzheimer's disease and periventricular white matter lesions which are believed to be of vascular origin, is frequently found in multi-infarct dementia, a dementia of vascular type. A study found prominent white matter changes in MRI in 29 patients; it also found the white matter changes being mild in Alzheimer's disease patients which may be partly age related or partly due to ischaemic events.[33] On the other hand, autopsy studies show minor cortical atrophy in the absence of cognitive decline in normal controls while it also found that cortical atrophy in Alzheimer's disease cases was 20 to 25% greater than that in controls.[34]

In order to find out whether the neuro-radiological findings from the present study can be corroborated with

cognitive functioning of the two groups (Figure 3, 4, 5): Group 1 (with periventricular hyper-intensity) and Group 2 (global cortical atrophy), cognitive status of the participants (as found in Study 1) have been compared with that of Study 2.

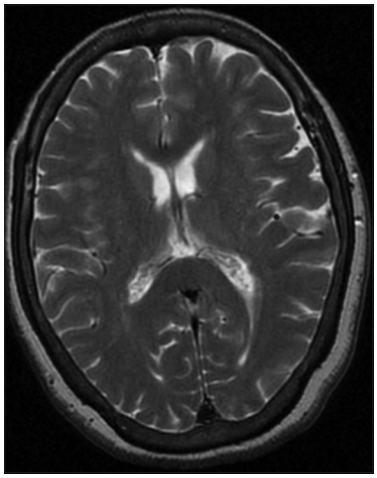

Figure 3: Magnetic resonance imaging (MRI) showing white matter hyper-intensity in a 54-year old female examined in the study.

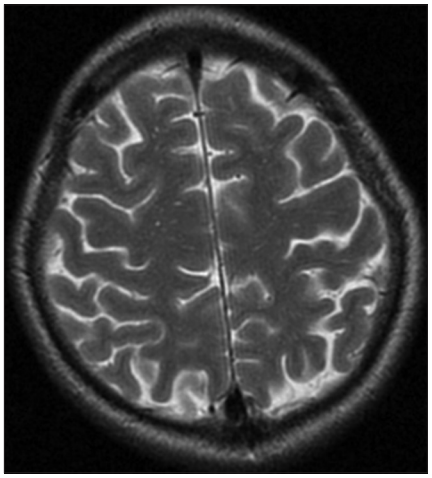

Figure 4: Magnetic resonance imaging (MRI) showing global cortical atrophy in a 51-year-old male examined in the study.

A comparison of cognitive profiles of the two groups show that the group with periventricular hyper-intensity of white matter differed from the group with global cortical atrophy significantly with respect to only single domain of cognitive function, i.e. visuo-constructional ability: the first group having relatively intact functioning than the second group. The test of visuo-constructional ability as examined in the current study involves copying of simple geometrical figures. As the literature reveals copying figures are tasks of constructional praxis and it is a complex process which involves multiple cognitive mechanisms including visual object recognition, routines of spatial coding and binding, attention, and planning, to name a few.[35] Cognitive functions that are important for these tasks include executive abilities (e.g. planning), attention to global and local aspects of the figures and visuospatial abilities (e.g. processing of shapes, understanding the relationships among different component parts of the figures). Visuo-constructive dysfunction leads to difficulties with spatial organisation of visual information, integration, and to problems with assembly and drawing.[36] Visuospatial dysfunction leads to a deficit in the representation and integration of images, and spatial localisation and object tracking. In cases of both visuo-constructional ability and visuo-spatial ability, visual processing pathways need to be intact. For movement analysis and visuo-motor coordination, occipito-parietal or dorsal stream pathways are required; inferior occipito-temporal or ventral stream pathway is required for object perception (shape and colour) while medial superior temporal area is important for visuospatial functions.[36] Visuo-constructional functions are usually attributed to parietal lobe, especially posterior parietal lobe[34] and in cases of tasks with increasing complexity, the role of frontal lobe is acknowledged.[37] The importance of posterior parietal lobe is evidenced by functional imaging studies also, which shows that constructional deficits are associated with posterior parietal lobe activation,[38,39] especially to figure copying tasks.[40] Though periventricular white matter pathology is associated with some amount of frontal pathology,[41] visuo-constructional task is a principally parietal function and in contrast to individuals with periventricular hyper-intensity of white matter (usually related to vascular pathology), cerebral atrophy (cortical gray matter pathology) impairs this function.

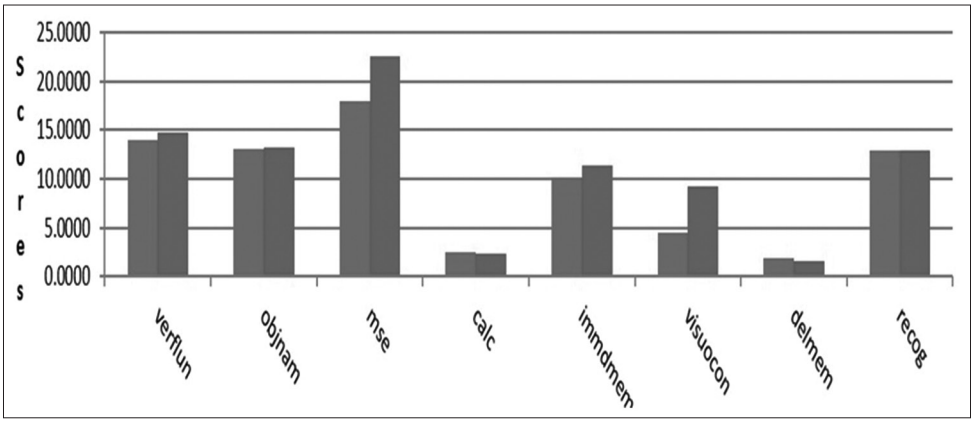

Figure 5: Graph showing difference of performance on different subtests of Kolkata Cognitive Screening Battery (KCSB) between Group 1 (with periventricular hyper-intensity) and Group 2 (global cortical atrophy). Abbreviations of sub-test names of KCSB used in graph- verbal fluency: verflun; object naming: objnam; mental status examination: mse; calculation: calc; immediate memory: immdmem; visuo-construction: visuocon; delayed memory: delmem; recognition: recog.

Conclusion

The present researchers has focused on a sample of community living elderly people (non-institutionalised) reporting with symptoms of peripheral nervous system disorder to the MRI clinic in their attempt to identify undiagnosed cognitive dysfunction at the community level. As stated earlier, the study has been envisioned as pilot work for a larger study and has some limitations. Firstly, the data has been collected purposively from the community living elderly people with symptoms of peripheral nervous system disorder from MRI clinic. In further attempt, the researchers would like to continue with the investigation by random collection of data by door to door home visit in the community. Secondly, the sample size is very small and thirdly, in the set up of MRI clinic, further detailed neuropsychological assessment was not possible. A larger sample and a detailed assessment of cognitive functions would be more revealing and informative. Whatever may be the limitations, the present study shows that though community living elderly adults in this small subsample of the population under study do not show any manifestation of dementing illness at clinical level, the participants actually exhibit underlying pathological process which may be manifested through several peripheral symptoms and can be detected with neuropsychological testing in conjunction with neuroimaging. This may help in identifying early cognitive impairment so that the cognitive and functional deterioration can be restricted therapeutically before it progresses into irreversible conditions like dementia.

Acknowledgements

The study has been conducted as a part of a research programme funded by University Grants Commission (UGC) under Centre with Potential for Excellence (CPEPA) Scheme. We gratefully acknowledge the valuable help provided by the funding agency and those colleagues who have helped us to carry out the study at CPEPA centre, University of Calcutta and Eko Diagnostics without whose help we could not have carried out the research.

References

1. Das SK, Banerjee TK, Mukherjee CS, Bose P, Biswas A, Hazra A, *et al*. An urban community-based study cognitive function among non-demented elderly population in India. Neurol Asia. 2006;11:37-48.
2. Ganguli M, Ratcliff G, Chandra V, Sharma S, Gilby J, Pandav R, *et al*. Hindi version of the MMSE: the development of a cognitive screening instrument for a largely illiterate rural elderly population in India. Int J Geriatr Psychiatr. 1995;10:367-77.
3. Katz S. Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. J Am Geriatr Soc. 1983;31:721-7.
4. Timiras PS, editor. Physiological basis of aging and geriatrics. 4th ed. CRC Press; 2007.
5. Adhikari S, Basu J, Das SK, Misra AK. Effects of age, stage of disease, and educational level on cognitive dysfunction in non-demented idiopathic Parkinsonism: a preliminary report. Ind Psychiatry J. 2012;21:32-8.
6. Buckner RL. Memory and executive function in aging and AD: multiple factors that cause decline and reserve factors that compensate. Neuron. 2004;44:195-208.
7. Squire LR. Declarative and nondeclarative memory: multiple brain systems supporting learning and memory. J Cogn Neurosci. 1992;4:232-43.
8. Huppert FA. Memory function in dementia and normal aging: dimension or dichotomy? In: huppert FA, Brayne C, O'Connor DW, editors. Dementia and normal aging. Cambridge: cambridge University Press; 1994:291-330.
9. Chodosh J, Reuben DB, Albert MS, Seeman TE. Predicting cognitive impairment in high-functioning community-dwelling older persons: macArthur Studies of Successful Aging. J Am Geriatr Soc. 2002;50:1051-60.
10. Caamaño-Isorna F, Corral M, Montes-Martínez A, Takkouche B. Education and dementia: a meta-analytic study. Neuroepidemiology. 2006;26:226-32.
11. Devraj, Singh VB, Ola V, Meena BL, Tundwal V, Singh K. Cognitive function in elderly population: an urban community based study in north-west Rajasthan. Journal of Indian Academy of Clinical Medicine. 2014;15:87-90.
12. Hong YJ, Yoon B, Shim YS, Cho AH, Lee ES, Kim YI, *et al*. Effect of literacy and education on the visuoconstructional ability of non-demented elderly individuals. J Int Neuropsychol Soc. 2011;17:934-9.
13. Le Carret N, Lafont S, Mayo W, Fabrigoule C. The effect of education on cognitive performances and its implication for the constitution of the cognitive reserve. Dev Neuropsychol. 2003;23:317-37.
14. Stern Y. What is cognitive reserve? Theory and research application of the reserve concept. J Int Neuropsychol Soc. 2002;8:448-60.
15. Stern Y. The concept of cognitive reserve: a catalyst for research. J Clin Exp Neuropsychol. 2003;25:589-93.
16. Manly JJ, Jacobs DM, Sano M, Bell K, Merchant CA, Small SA, *et al*. Effect of literacy on neuropsychological test performance in nondemented, education-matched elders. J Int Neuropsychol Soc. 1999;5:191-202.
17. Weiss E, Siedentopf CM, Hofer A, Deisenhammer EA, Hoptman MJ, Kremser C, *et al*. Sex differences in brain activation pattern during a visuospatial cognitive task: a functional magnetic resonance imaging study in healthy volunteers. Neurosci Lett. 2003;344:169-72.
18. Keller K, Menon V. Gender differences in the functional and structural neuroanatomy of mathematical cognition. Neuroimage. 2009;47:342-52.
19. Frederikse ME, Lu A, Aylward E, Barta P, Pearlson G. Sex differences in the inferior parietal lobule. Cereb Cortex. 1999;9:896-901.
20. Sabatini U, Boulanouar K, Fabre N, Martin F, Carel C, Colonnese C, *et al*. Cortical motor reorganization in akinetic patients with Parkinson's disease: a functional MRI study. Brain. 2000;123:394-403.
21. Sowell ER, Peterson BS, Kan E, Woods RP, Yoshii J, Bansal R, *et al*. Sex differences in cortical thickness mapped in 176 healthy individuals between 7 and 87 years of age. Cereb Cortex. 2007;17:1550-60.
22. Zaidi ZF. Gender differences in human brain: a review. The Open Anatomy Journal. 2010;2:37-55.
23. Razani J, Casas R, Wong JT, Lu P, Alessi C, Josephson K. Relationship between executive functioning and activities of daily living in patients with relatively mild dementia. Appl Neuropsychol. 2007;14:208-14.
24. Cahn-Weiner DA, Boyle PA, Malloy PF. Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. Appl Neuropsychol. 2002;9:187-91.
25. Cahn-Weiner DA, Farias ST, Julian L, Harvey DJ, Kramer JH, Reed BR, *et al*. Cognitive and neuroimaging predictors of instrumental activities of daily living. J Int Neuropsychol Soc. 2007;13:747-57.
26. Pihlajamäki M, Tanila H, Hänninen T, Könönen M, Laakso M, Partanen K, *et al*. Verbal fluency activates the left medial temporal lobe: a functional magnetic resonance imaging study. Ann Neurol. 2000;47:470-6.
27. Collette F, Hogge M, Salmon E, Van der Linden M. Exploration of the neural substrates of executive functioning by functional neuroimaging. Neuroscience. 2006;139:209-21.
28. Baldo JV, Schwartz S, Wilkins D, Dronkers NF. Role of frontal versus temporal cortex in verbal fluency as revealed by

voxel-based lesion symptom mapping. J Int Neuropsychol Soc. 2006;12:896-900.
29. Paulesu E, Goldacre B, Scifo P, Cappa SF, Gilardi MC, Castiglioni I, *et al*. Functional heterogeneity of left inferior frontal cortex as revealed by fMRI. Neuroreport. 1997;8:2011-7.
30. Arciniegas DB, Anderson CA, Filley CM, editors. Behavioral neurology and neuropsychiatry. Cambridge University Press; 2013.
31. West S, Mc Cue R, Golden C. Does memory predict decline in activities of daily living in older adults with Alzheimer's disease? Archives of Assessment Psychology. 2012;2:32-43.
32. Woodruff-Pak DS. The neuropsychology of aging. Hoboken, NJ: Blackwell Publishing; 1997.
33. Erkinjuntti T, Ketonen L, Sulkava R, Sipponen J, Vuorialho M, Iivanainen M. Do white matter changes on MRI and CT differentiate vascular dementia from Alzheimer's disease? J Neurol Neurosurg Psychiatry. 1987;50:37-42.
34. Mouton PR, Martin LJ, Calhoun ME, Dal Forno G, Price DL. Cognitive decline strongly correlates with cortical atrophy in Alzheimer's dementia. Neurobiol Aging. 1998;19:371-7.
35. Chechlacz M, Novick A, Rotshtein P, Bickerton WL, Humphreys GW, Demeyere N. The neural substrates of drawing: a voxel-based morphometry analysis of constructional, hierarchical, and spatial representation deficits. J Cogn Neurosci. 2014;26:2701-15.
36. Marasescu R, Cerezo Garcia M, Aladro Benito Y. Impairment of visuospatial/visuoconstructional skills in multiple sclerosis patients: the correlation with regional lesion load and subcortical atrophy. [Article in English, Spanish] Neurologia. 2016;31:169-75.
37. Choi JS, Kang DH, Kim JJ, Ha TH, Lee JM, Youn T, *et al*. Left anterior subregion of orbitofrontal cortex volume reduction and impaired organizational strategies in obsessive-compulsive disorder. J Psychiatr Res. 2004;38:193-9.
38. Grossi D, Trojano. Constructional apraxia. In: Denes G, Pizzamiglio L. Handbook of clinical and experimental neuropsychology. Hove: Psychology Press; 1998:441-91.
39. de Renzi E. Visuospatial and constructional disorders. In: Farah MJ, editor. Behavioral neurology and neuropsychology. New York, NY: McGraw-Hill; 1997:297-307.
40. Ogawa K, Inui T. The role of the posterior parietal cortex in drawing by copying. Neuropsychologia. 2009;47:1013-22.
41. Filley CM. White matter and behavioral neurology. Ann N Y Acad Sci. 2005;1064:162-83.

Ghose S, Das S, Sadhu A. Cognitive dysfunction in urban elderly people: an exploratory study using neuropsychological and neuroimaging perspective. Open J Psychiatry Allied Sci. 2017;8:141-7. doi: 10.5958/2394-2061.2017.00011.8. Epub 2017 May 9.

Source of support: University Grants Commission (UGC) under Centre with Potential for Excellence (CPEPA) Scheme. **Declaration of interest:** None.