REVIEW ARTICLE

DYSCALCULIA, CAUSES, INTERVENTION AND PAKISTANI SCENARIO

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ABSTRACT

Dyscalculia is a learning disability that affects many children and adults. It has negative consequences for the children, youth and society at large. Research evidence has shown a number of causal factors responsible for dyscalculia. These are impairments in number sense also called "core deficit hypothesis", accessing numerical magnitudes from symbols known as "access hypothesis" and neurological impairment in the horizontal intra parietal sulcus. Many researchers have developed game based intervention programs showing their effectiveness in improving children numerical abilities. Research and interventions evidence to alleviate dyscalculia is very scarce in Pakistan. Future research directions and suggestion have been mentioned to carry out and to improve dyscalculic children's numerical abilities.

KEY WORDS

Dyscalculia, Numerical cognition, Horizontal intra parietal sulcus (HIPS), Approximate number system (ANS).

INTRODUCTION

Number skills are very important for human beings. Poor numeracy skills result in restricted job access, unemployment, low paying manual workers, lifelong struggle at workplace and in dealing with day to day demands of life, poorer educational access, homelessness, low self-esteem etc. Deficiency in numerical skills is called dyscalculia. It is very critical to identify the dyscalculic children as soon as possible, so that the reasons and required interventions could be identified and implemented to avoid lifelong effects of being low at math. Researchers have used different terminology for defining dyscalculia such as developmental dyscalculia[1,2], mathematical disabilities[3-5], arithmetic learning difficulties[6,7] and math learning difficulties[8].

Developmental dyscalculia has been defined as "mathematical ability that falls substantially below then expected level for the individual's chronological age, measured intelligence and age appropriate education. It interferes with academic achievement and daily living activities that require math skills"[9]. Developmental dyscalculia is a structural disorder, resulting from genetic or congenital disorder in those parts of the brain involved in mathematical cognition without a general difficulty in cognitive functions[10]. Dyscalculia appears in early school years in children as delay in learning, counting and arithmetic strategies, and continues into adulthood. Dyscalculic adults were significantly slower and low on accuracy in answering simple arithmetic problems, counting sets of objects even after controlling for co morbidity factors and above average IQ.

CAUSES OF DYSCALCULIA

Developmental Dyscalculia (DD) is not an outcome of dysfunctions in general domain or basic cognitive abilities like semantic or working memory, spatial abilities or linguistic abilities[2,11]. There is well established behavioral, neuropsychological and neuro imaging evidence for domain specific and brain based impairments as cause of dyscalculia.

Human shares approximate representation of numerosity with non-human animals[12,13]. Approximate number system (ANS) is already present in newborns infants[14,15] and its acuity increases over the period of development[16,17]. ANS is important for the acquisition of mathematical knowledge[17]. Symbolic tasks such as subtraction or approximation activate and map on to the number sense[18]. Number sense is correlated and predictive of later math achievement[19-23]. Number sense can be measured through non symbolic tasks like arrays of dots or sequence of sounds/tones, involving addition, subtraction, comparison, and estimation[24-26]. An impairment of approximate number system (ANS), is the core deficit of DD[21,27-33]. Children with dyscalculia or math learning difficulties (MLD) have impaired ANS acuity[2, 18, 34-40]. However, the core deficit is not always found by other researchers[41-44].

Children with MLD have problem in representation of closer magnitudes like discriminating a set of five objects from six and respond to these sets as if they were the same as compared with the normally developing children[45]. Deficit in number sense is related to structural or functional impairment in the horizontal intra parietal sulcus (HIPS) region.

Alternatively, researchers think that DD results because of deficit to automatically linking and mapping symbols on to magnitude representations called "access hypothesis", reflecting a specific impairment in symbolic processing[44,46-48]. Children with MLD were slower at accessing the quantities from numerical symbols as compared with their peers, suggesting a mapping deficit[36,44,49]. Children with dyscalculia showed impairments on reaction time and accuracy while processing arithmetic facts[2].

There are specialized brain areas in the parietal lobe responsible for numerical and arithmetic abilities[50]. Horizontal Intra Parietal Sulcus (HIPS) gets activated in number sense tasks such as estimating, subtracting approximating and comparing the size of numbers in the arithmetic and numerical processing[18,51-53]. Research evidence from patients with brain lesions showed that left Intra Parietal Sulcus (IPS) and the angular gyrus are critical for normal mathematical performance[54]. Reduced grey matter has been observed in areas involved in basic numerical processing, in the right IPS[55] and in the IPS bilaterally[56] and deficient recruitment of neural resources while processing analogue magnitude of numbers[57]. Neuro imaging evidence showed that parietal cortex regions are structurally or functionally impaired in dyscalculics[55,56,58-62].

Dyscalculia can be identified through standardized tests like PAT, Woodcock Johnson, WRAT, Key Math, TEMA-3, CMAT.

REMEDIATION AND INTERVENTION

For the remediation of dyscalculia adaptive computerized training programs have been developed based on behavioral and cognitive neuroscience evidence. Number race was developed to improve the precision of numerical magnitude representation in dyscalculics by retraining the approximate number system and cementing its link with symbols[63]. Five weeks of computer assisted training of number race game improved subitizing, number comparison, and subtraction performance of children with math learning difficulties[64]. Computer based training program with DD children showed improved spatial representation of numbers and the number of correctly solved mathematical problems[61].

Neuro scientific, behavioral and intervention research evidence can be used to develop new ways to strengthen the sense of number using learning technologies[65].These findings provide support for remediation programs to be used for developmental dyscalculia involving exercises to retrain the approximate number system and to strengthen its links with symbols[63]. Computer based intervention (number race and Graphogame-math) with low numeracy skill children improved children skills in number comparison only and not in other areas of number skills[66]

DYSCALCULIA IN PAKISTAN.

There is dearth of researches carried out in Pakistan on dyscalculia. There is no systemic research evidence reflecting upon the studies carried out on Pakistani children and adults.

Few studies have been conducted in Pakistan on overall learning disabilities in terms of validation of checklists to measure learning disabilities. Researchers conducted a validation study of learning disabilities checklist in public schools of Pakistan, and reflected on overall coexistence of reading, writing and mathematical disability[67]. However, this study did not specifically reflected on dyscalculia. No studies have been found specifically on the topic of dyscalculia with respect to Pakistani population. So it is extremely important to identify the current situation of dyscalculia, its causes with research evidence and plan intervention studies for Pakistani children suffering from dyscalculia.

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