EVALUATION OF COGNITIVE SKILLS AND MOTOR ABITITIES OF PRIMARY SCHOOL CHILDREN

A dissertation submitted in fulfillment of the requirement for the degree of Doctor of Philosophy (Science) in the Vidyasagar University

By

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Certificate

This is to certify that the thesis entitled **"Evaluation of cognitive skills and motor abilities of primary school children"** submitted to the Vidyasagar University by **Sourav Manna** for the award of the degree of Doctor of Philosophy (Science), is a bona fide record of research work carried out by him under my supervision and guidance. Sourav Manna has completed all the prescribed requirements for the award of the degree in accordance with terms and conditions laid down for the Ph.D. examination of Vidyasagar University.

The research report and results embodied in this thesis have not submitted for any other degree or diploma in any other University or Institute.

(P.C. DHARA)

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Declaration

I hereby declared that the research work presented in the thesis entitled "**Evaluation of cognitive skills and motor abilities of primary school children"**, has been carried out by me in the Ergonomics and Sports Physiology Division of Department of Human Physiology with Community Health, Vidyasagar University, for the fulfillment of the requirement for the degree of Doctor of Philosophy. It is also declared that, the research report and results presented in this investigation is original and has not been submitted in part or full for the award of any Degree or Diploma of any University or Institute.

…………………………….

(Sourav Manna)

Dedicated to

My father

Mr. Sukumar Manna

&

My mother

Mrs. Chhanda Rani Manna

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List of Abbreviations

ALA - Alpha Linolenic Acid

ANOVA- Analysis of Variance

BDNF- Brain Derived Neurotrophic Factor

BMI - Body Mass Index

BOLD - Blood Oxygen Level Dependent Signal

CCT - Colour Cancellation Test

CTT - Colour Trail Test

DH - Dominant Hand

DHA - Docosahexaenoic Acid

EPA - Eicosapentanoic Acid

EF - Executive Function

fMRI - Functional Magnetic Resonance Imaging

Kcal - Kilocalorie

LC-PUFA - Long Chain Poly unsaturated fatty acid

LES - Lower Economic Status

LOT - Learning Of Trial

MES - Middle Economic Status

NDH - Non Dominant Hand

PCT - Picture Completion Test

PET- Positron Emission Tomography

PUFA - Poly Unsaturated Fatty Acid

RAVLT - Ray's Auditory Verbal Learning test

REC - Recognition

RT - Reaction Time

SD - Standard Deviation

SES - Socioeconomic Status

SPECT- Single Photon Emission Computed Tomography

UES - Upper Economic Status

WHO - World Health Organization

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Introduction

Chapter I

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1. *Introduction:*

From the beginning of the life after birth a child undergoes growth and development. Physical growth is an increase in size. Development is growth in function and capability. Both processes highly depend on genetic, nutritional, and environmental factors. Along with the physical growth the cognitive skill and motor ability also show a pattern of growth and development in the children.

The term cognition (Latin: *cognoscere*, "to know", "to conceptualize" or "to recognize") refers to a faculty for the processing of information, applying knowledge, and changing preferences. Cognition, or cognitive processes, can be natural or artificial, conscious or unconscious. These processes are analyzed from different perspectives within different contexts, notably in the fields of linguistics, anaesthesia, neurology, psychology, philosophy, anthropology, systemic and computer science. Within psychology or philosophy, the concept of cognition is closely related to abstract concepts such as mind, reasoning, perception, intelligence, and learning. Thomas Aquinas divided the study of behaviour into two broad categories: cognitive (how we know the world), and affect (feelings and emotions). Consequently, this description tends to apply to processes such as memory, association, concept formation, language, attention, perception, action, problem solving and mental imagery (Bjorklund et al. 2004). Relatively recent fields of study such as cognitive science and neuropsychology aim to bridge this gap, using cognitive paradigms to understand how the brain implements these information-processing functions or how pure information-processing systems (e.g., computers) can simulate cognition. It has been observed since antiquity that language acquisition in human children fails to emerge unless the children are exposed to language. Thus, language acquisition is an example of an emergent behaviour. In education, for instance, which has the explicit task in society of developing child cognition, choices are made regarding the environment and permitted action that lead to a formed experience. In social cognition, face perception in human babies emerges by the age of two months. Very young children appear to have some skill in navigation. This basic ability to infer the direction and distance of unseen locations develops in ways that are not entirely clear. Evidences show that it involves the development of complex language skills between 3 and 5 years. Also, this skill depends importantly on visual experience, because congenitally blind individuals have been found to have impaired abilities to infer new paths between familiar locations. The children less than 72 hours old can perceive some complex things as biological motion (Pica et al. 2003). However, it is unclear how visual experience in the first few days contributes to this perception. Young children seem to be predisposed to think of biological entities (e.g., animals and plants) in an essentialistic way (Thomton and Stephanie ,2003). This means that they expect such entities (as opposed to, e.g., artefacts) to have many traits such as internal properties that are caused by some "essence, well-studied process and consequence of cognitive development is language acquisition. Other traditions, however, have emphasized the role of learning and social experience in language learning. Language development is sometimes separated into learning of phonology, morphology, syntax, semantics, and discourse or pragmatics.

1.1 Parameters of cognitive and motor skills:

There are several characteristics that constitute the cognitive and motor skills of a person. Some of the important characteristics are pointed out below:

Attention: It is the behavioural and cognitive process of selectively concentrating on a discrete aspect of information, whether deemed subjective or objective, while ignoring other perceivable information. It is the taking possession by the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought. Focalizations, concentration of consciousness are of its essence. Attention has also been referred to as the allocation of limited processing resources (Anderson 2004).

There are different types of attention which are briefly discussed below:

Selective attention

When faced with a number of environmental factors or stimuli, the human brain naturally responds by selecting a particular aspect or factor to focus on. This is known as selective attention. Selective attention is the ability to select from the many factors or stimuli and focus to only one that you prefer or your brain selects. This is not really a special and hard to achieve kind of attention. Almost all people use this cognitive ability almost all the time. Every day, people are usually exposed to a number of environmental factors at home, at the school, at the office, etc but their brains respond by focusing only to the particular factors that matter most or those that people choose to focus on. By better understanding it however, the person is better able to select the appropriate stimuli to devote his or her attention .

Divided attention

This kind of attention related to cognition is an interesting one, divided attention. Divided attention is the ability of an individual to focus or concentrate on two or more environmental factors, stimuli, or activities simultaneously. In its simplest form of explanation, experts call it the ability to multi-task. Multi-tasking is considered a desirable talent for those who are gifted with this ability. But, this means that it will be very difficult for other people to acquire this skill. Divided attention or the ability to multi-task can be learned through practice or gaining expertise in a certain kind of activity.

Some instances of divided attention are easier to manage than others. For example, straightening up the home while talking on the phone may not be hard if there's not much of a mess to focus on it. Texting while you are trying to talk to someone in front of you, however, is much more difficult. Sustained attention

It’s pretty simple to catch anyone’s attention but it is certainly a challenge to sustain or keep it for any considerable amount of time. Sustained attention is the ability to keep that focus or concentration for long periods of time even if the individual is exposed to the repetitive action or activity. This is the kind of attention that is usually used for majority of the learning and working activities like listening to a teacher lecture the whole hour, read books and notes the whole night to review, in answering test or exercise questions, completing an extensive project, or perhaps, regularly working on a repetitive task. This kind of attention should be very beneficial but it is the kind that is oftentimes very hard to acquire or achieve. (Barkley, 1997) Sustained attention is also commonly referred to as one's attention span. It takes place when we can continually focus on one thing happening, rather than losing focus and having to keep bringing it back. People can get better at sustained attention as they practice it.

Executive attention

If anyone is inclined to do to focus intently enough to create goals and monitor your progress, He or she is displaying executive attention. Executive attention is particularly good at blocking out unimportant features of the environment and attending to what really matters. It is the attention we use when we are making steps toward a particular end.

For example, maybe you need to finish a research project by the end of the day. You might start by making a plan, or you might jump into it and attack different parts of it as they come. You keep track of what you've done, what more you have to do, and how you are progressing. You are focusing on these things in order to reach the goal of a finished research paper. That is using your executive attention.

Visual Scanning and Visual Tracking

Visual scanning is the ability to use vision to search in a systematic manner, such as top to bottom and left to right. A child needs to use visual scanning to avoid obstacles when navigating their environment. Smooth visual scanning is required for reading.

Visual tracking is defined as efficiently focusing on an object as it moves across a person's visual field. This skill is important for daily activities, including reading, writing, drawing, and playing.

Verbal Learning

Verbal learning is the process of acquiring, retaining and recalling of verbal material. At its most elementary level, it can be defined as a process of building associations between a stimulus and a response, with both of them being verbal. At a broader level, verbal learning includes the processes of organizing the stimulus material by the learner and the related changes in the learner's behavior.

Declarative memory

Long-term memory is often divided into two further main types: explicit (or declarative) memory and implicit (or procedural) memory. Declarative memory ("knowing what") is memory of facts and events, and refers to those memories that can be consciously recalled (or "declared").

Declarative memory can be further sub-divided into episodic memory and semantic memory.

Episodic memory represents our memory of experiences and specific events in time in a serial form, from which we can reconstruct the actual events that took place at any given point in our lives. It is the memory of autobiographical events (times, places, associated emotions and other contextual knowledge) that can be explicitly stated. Individuals tend to see themselves as actors in these events, and the emotional charge and the entire context surrounding an event is usually part of the memory, not just the bare facts of the event itself.

Semantic memory, on the other hand, is a more structured record of facts, meanings, concepts and knowledge about the external world that we have acquired. It refers to general factual knowledge, shared with others and independent of personal experience and of the spatial/temporal context in which it was acquired. Semantic memories may once have had a personal context, but now stand alone as simple knowledge. It therefore includes such things as types of food, capital cities, social customs, functions of objects, vocabulary, understanding of mathematics, etc. Much of semantic memory is abstract and relational and is associated with the meaning of verbal symbols.

Phonemic fluency

Verbal fluency (or phonemic fluency) tests are a kind of psychological test in which participants have to say as many words as possible from a category in a given time (usually 60 seconds). This category can be semantic, such as animals or fruits, or phonemic, such as words that begin with letter p (*Deutsch, 1995*).

The semantic fluency test is sometimes described as the category fluency test or simply as "freelisting". The COWAT (Controlled oral word association test) is the most employed phonetic variant (*Loonstra, 2001).*

Reaction time

Reaction time (RT) is the elapsed time between the presentation of a sensory stimulus and the subsequent behavioural response. In psychometric psychology it is considered to be an index of processing speed (Jensen, 2006). That is, it indicates how fast the individual can execute the mental operations needed by the task at hand. In turn, speed of processing is considered an index of processing efficiency. The behavioural response is typically a button press but can also be an eye movement, a vocal response, or some other observable behaviour.

Moreover, RT plays a very important role in our lives as its practical implications may be of great consequences. Factors that can affect the average human RT include age, sex, left or right hand, central versus peripheral vision, practice, fatigue, fasting, breathing cycle, personality types, exercise, and intelligence of the subject.

Simple reaction time is the motion required for an observer to respond to the presence of a stimulus. For example, a subject might be asked to press a button as soon as a light or sound appears (Kosinski, and Cummings 1999). *Choice* reaction time (CRT) tasks require distinct responses for each possible class of stimulus. For example, the subject might be asked to press one button if a red light appears and a different button if a yellow light appears.

Motor skills

Motor skills are movements and actions of the muscles. Typically, they are categorized into two groups: gross motor skills and fine motor skills. Gross motor skills are involved in movement and coordination of the arms, legs, and other large body parts and movements. They participate in actions such as running, crawling, swimming, etc. Fine motor skills are involved in smaller movements that occur in the wrists, hands, fingers, and the feet and toes. They participate in smaller actions such as picking up objects between the thumb and finger, writing carefully, and even blinking. These two motor skills work together to provide coordination.

Fine motor skill or Dexterity

Fine motor skill (or dexterity) is the coordination of small muscles, in movements—usually involving the synchronization of hands and fingers—with the eyes. The complex levels of manual dexterity that humans exhibit can be attributed to and demonstrated in tasks controlled by the nervous system. Fine motor skills aid in the growth of intelligence and develop continuously throughout the stages of human development.

Gross motor skills

Gross motor skills are the abilities usually acquired during infancy and early childhood as part of a child's motor development. By the time they reach two years of age, almost all children are able to stand up, walk and run, walk up stairs, etc. These skills are built upon, improved and better controlled throughout early childhood, and continue in refinement throughout most of the individual's years of development into adulthood. These gross movements come from large muscle groups and whole body movement. These skills develop in a head-to-toe order. The children will typically learn head control, trunk stability, and then standing up and walking (Williams et al., 2009).

1.2 Neurophysiology cognitive and motor skills:

The cognitive and motor abilities are related to the functions of the brain. Brain development is an organized and highly dynamic multistep process, which was genetically determined, epigenetically directed and environmentally influenced (Tau and Peterson 2010). This process continues both through childhood and adolescence, the developmental period during which the body and brain emerge from an immature state to adulthood (Spear 2000, Steinberg and Morris 2001). Although total brain size become approximately 90% of its adult size by age six, it was well known that the gray and white matter subcomponents of the brain continue to undergo dynamic changes throughout adolescence (Paus 2005)

There was increasing consensus on the overall pattern of gray matter development over the course of childhood and adolescence: in childhood a global increase of cortical gray matter volume takes place, peaking around the onset of puberty, which is then followed by a gradual decrease in adolescence and early adulthood (Gogtey and Thompson, 2010 ., Raznahan et al. 2011). Cortical thinning occurs throughout adolescence and extends well into adulthood, but patterns (e.g. linear, quadratic, cubic) differ across brain regions and are also dependent on the studied age range (Thamnes et al. 2009 , Raznahan et al. 2011). In contrast, total white matter volume increases even until approximately the fifth decade of life and declines thereafter (Paus 2010a). For sub cortical regions, developmental patterns are less clear. For example, age-related volume increases for the hippocampus and amygdala (Ostby et al. 2009, Taki et al. 2012), and age-related volume decreases in the caudate, putamen, pallidum and accumbency have been reported (Sowell et al. 2007, Ostby et al. 2009).

1.3 Factors related to cognitive and motor abilities:

Age-related changes in cognitive function vary considerably across individuals and across cognitive domains, with some cognitive functions appearing more susceptible than others to the effects of aging. Much of the basic research in cognitive aging has focused on attention and memory, and indeed it may be that deficits in these fundamental processes can account for much of the variance observed in higher-level cognitive processes. The mapping of cognitive processes onto neural structures constitutes a relatively recent research enterprise driven largely by advances in neuroimaging technology. Early work in this area focused on establishing brain regions associated with different kinds of cognitive performance and revealed that normally aging older adults often appear to activate different brain structures than young people when performing cognitive tasks. The reasons for these differences are a matter of considerable debate. Ultimately, the understanding of age-related changes in cognition will require a parallel understanding of the age-related changes in the brain and the underlying mechanisms responsible for those changes (Glisky 2007) .

Reviews of cognitive aging distinguish between processes showing gradual declines across the life-span and those that remain stable until advanced age (Borson 2005). Basic mechanisms common to many cognitive processes, including perceptual and thinking speed, numerical ability, working memory, and encoding and retrieval of new information, appear to show small but continuous, more or less linear declines across the entire adult life span from the early 20's through the 80's, though the magnitude and precise trajectory of these normal changes is debated. Most functions that depend on stable knowledge stores and well-practiced tasks remain stable into old age, and some – including 'wisdom', the superior judgment and insight born of life experience and resulting strategic efficiencies – improve with age.

Age may an influencing factor for motor skills of the humans. Knowledge about aging of perceptual-motor skills is based almost exclusively on cross-sectional studies. Rodrigue et al. (2005) (examined age-related changes in the retention of mirror-tracing skills in healthy adults who practiced for 3 separate days at baseline and retrained 5 years later at follow-up, they concluded that although the long-term retention of acquired skills declines with age, older adults still retain the ability to learn the skill. Moreover, those who maintained a processing speed comparable with that of the younger participants evidenced no age-related performance decrements on the mirror-drawing task.

Gender difference may be found in cognitive and motor abilities of the human subjects. Mental skills or cognitive abilities include attributes like perception, attention, memory (short-term or working and long-term), motor, language, visual and spatial processing, and executive functions (Michelon 2006). These cognitive attributes may be different in males and females. Generally, females show advantages in verbal fluency, perceptual speed, accuracy and fine motor skills, while males outperform females in spatial, working memory and mathematical abilities (Sherwin 2003 ., Zaidi 2010)

Gender differences in cognitive abilities have been widely analyzed in the psychological and neuropsychological literature (Hedges and Nowell, 1995; Kimura 1999., Weiss and Kemmlera 2003).Three major differences in cognitive abilities between men and women have generally been reported: (a) higher verbal abilities, favouring women; (b) higher spatial abilities, favouring men; and (c) higher arithmetical abilities, also favouring men. However, differences in calculation abilities have, at times, been interpreted as a result of men's superior spatial abilities (Benbow 1988., Geary 1996); hence, these three differences could be reduced to just two. Besides age, gender has also been found to affect children's developing motor skills, although relevant empirical data are often contradictory. Researchers either report gender differences in various motor tasks (Brito and Santos-Morales, 2002., Largo et al. 2001., Largo et al. 2003) or they focus on the age in which boys and girls attain specific motor skills (Gidley et al. 2007). For instance, according to Denckla(1973), school-aged girls seem faster and better synchronized than boys; however these differences are not obvious during adolescence. Additionally, it has been reported that boys' ball skills develop earlier than girls', while girls present manual dexterity skills earlier than boys (Giagazoglou et al. 2011., Junaid and Fellowes, 2006). Regarding balancing tasks, previous findings showed that girls outperform boys (Engel et al. 2010., Gabbard, 2004), while other suggest small gender differences (Venetsanou and Kambas, 2011).

Socioeconomic status is taken as a marker of different developmental factors of the human health and wellbeing. Socioeconomic status (SES) is an economic and sociological combined total measure of a person's work experience and of an individual's or family's economic and social position in relation to others, based on income, education, and occupation. When analyzing a family's SES, the household income, earners' education, and occupation are examined, as well as combined income, versus with an individual, when their own attributes are assessed. Socioeconomic status is typically broken into three categories (high SES, middle SES, and low SES) to describe the three areas a family or an individual may fall into. When placing a family or individual into one of these categories, any or all of the three variables (income, education, and occupation) can be assessed.

Socioeconomic status influence the quality of physical and psychological environment throughout development (Evans 2014). The psychological research established that poverty is powerful risk factor for poor developmental outcomes (Evan 2014) and poor cognitive and school performances (Brady et al. 2002).

Socio-economic status is strongly associated with the cognitive skill and motor ability and achievement of the children. Poverty has a significant effect on neuro-cognitive development, thereby limiting of the educational opportunities that compromise the social relationship required for socio-economic development (Hackman et al. 2010).The children who are living in a low income household or low socio-economic family, associated with deprivation of nutrient, maternal malnutrition of early sensory stimulation as well as exposure of environmental toxin (de Kloet et al. 2005., Cabeza et al. 2006). Living in poverty is also associated with poorer overall physical health, and having greater chance for mental disorders, affecting attention and anxiety and mood. Socio-economic status is the combination of education, income and occupation. The family of low socio-economic status have great difficulties to access a wide range of resource to promote and support of young children health and education as well as resources for social, emotional and cognitive development (Mueller and Parcel, 1981). The studies also related that memory system induces medial temporal structures including hippocampus that is important for memory consolidation and retrieval (Squire and Wixted, 2011). In several studies it was indicated that the memory and the performance were strongly and directly correlated with socio-economic status (Herrmann and Guadagno , 1997).

There are various environmental factors, beyond nutrition, that can affect the process of brain development, but one of the most crucial is environmental stressors, which impact the biology of the brain, mainly by influencing the body’s hormone function (Larson et al.1991; Lewis and Thomas, 1990). Toxic stress during the first years of life can affect the development of neural pathways and hormonal systems. Studies undertaken with both humans and animals show that elevated levels of cortisol over a prolonged period can alter the function of the neural system and change the architecture of regions of the brain that are essential for learning and memory. Furthermore, the circuits involved in the regulation of emotions are highly interactive with those associated with executive function (such as planning and decision-making), which are intimately involved in the development of abilities for problem-solving (Posner and Rothbart, 2000). In terms of basic brain function, emotions sustain executive function when they are properly regulated, but interfere with attention and decision-making when they are poorly controlled (Bush et al. 2000; Shonkoff and Phillips 2000).

A brain area that is particularly sensitive to the social environmental context is the prefrontal cortex (PFC). Experimental models with animals have shown that the prefrontal cortex is sensitive to a wide variety of factors, in the prenatal as well as the perinatal and postnatal periods. Prenatal stress (Fride and Weinstock, 1988), perinatal anoxia and the postnatal social environment, create changes in the dopaminergic system and the development of the prefrontal cortex (Sullivan and Brake, 2003).This has brought about copious amount of research in recent years analyzing the effects of SES on cognitive development, emphasizing the study of executive function (EF). EF is a construct that encompasses three different but related cognitive processes: (1) working memory, (2) cognitive flexibility, and (3) inhibition (Miyake et al. 2000). While various definitions and models have been proposed (Barkley 1997., Goldberg, 2001.,Lezak 1995), in general there is consensus about define them as higher-order cognitive processes, given that they have control over more automatic cognitive processes, inhibiting irrelevant stimuli, manipulating online information and regulating cognitive, emotional and /or behaviour activities towards the execution of a goal (Arán Filippetti and López, 2014). Given that the prefrontal cortex and the executive function follow a postnatal course of development (Diamond, 2002, Fuster, 2002), early life experience—both positive and negative—can influence their development.

Cognitive development is influenced by many factors, including nutrition. There is an increasing body of literature that suggests a connection between improved nutrition and optimal brain function. Nutrients provide building blocks that play a critical role in cell proliferation, DNA synthesis, neurotransmitter and hormone metabolism, and are important constituents of enzyme systems in the brain (Bhatnagar and Taneja, 2001, De Souza et al. 2011, Zimmermann, 2011). Bin development is faster in the early years of life compared to the rest of the body (Benton 2010), which may make it more vulnerable to dietary deficiencies.

Nyardi (2013) assessed the current research evidence for a link between nutritional intake in pregnancy and childhood and children's cognitive development. They discussed individual micronutrients like , vitamins , omega fatty acids, zinc, iron , iodine etc and single aspects of diet (breast feeding, breakfast, dietary pattern, diet quality etc), which represents earlier research in this area. They also pointed out the more encompassing aspects of diet, which have emerged as researchers became more interested in diet as a comprehensive measurement. The most recent research trend in this area suggests a broader analysis of the role of nutrition in neurocognitive development.

Malnutrition is a broad term which refers to both under nutrition (sub nutrition) and over nutrition. Individuals are malnourished, or suffer from under nutrition if their diet does not provide them with adequate calories and protein for maintenance and growth, or they cannot fully utilize the food they eat due to illness. People are also malnourished, or suffer from over nutrition if they consume too many calories Malnutrition can also be defined as the insufficient, excessive or imbalanced consumption of nutrients. Several different nutrition disorders may develop, depending on which nutrients are lacking or consumed in excess. Udani (1992) expressed malnutrition as the consequence of a combination of inadequate intake of protein, carbohydrates, micronutrients and frequent infections. In India malnutrition is rampant. In an earlier report WHO stated that for the years 1990–1997, 52% of Indian children less than 5 years of age suffered from severe to moderate under-nutrition (Upadhyaya et al .1992). About 35% of preschool children in sub-Saharan Africa are reported to be stunted (Leenstra et al. 2005). Malnutrition is associated with both structural and functional pathology of the brain. Structurally malnutrition results in tissue damage, growth retardation, disorderly differentiation, reduction in synapses and synaptic neurotransmitters, delayed myeination and reduced overall development of dendritic arborisation of the developing brain. There are deviations in the temporal sequences of brain maturation, which in turn disturb the formation of neuronal circuits (Udani 1992). Long term alterations in brain function have been reported which could be related to long lasting cognitive impairments associated with malnutrition (Levitski and Strupp, 1995). A wide range of cognitive deficits has been observed in malnourished children in India. In a study, malnourished children were assessed on the Gessell's developmental schedule from 4 to 52 weeks of age. Children with grades II and III malnutrition had poor development in all areas of behaviour, i.e., motor, adaptive, language and personal social (Upadhyaya et al., 1989). Rural children studying in primary school between the ages of 6–8 years were assessed on measures of social maturity (Vineland social maturity scale), visuomotor co-ordination (Bender gestalt test), and memory (free recall of words, pictures and objects). Malnutrition was associated with deficits of social competence, visuomotor coordination and memory. Malnutrition had a greater effect on the immediate memory of boys as compared with those of girls. Malnourished boys had greater impairment of immediate memory for words, pictures and objects, while malnourished girls had greater impairment of immediate memory for only pictures. Delayed recall of words and pictures of malnourished boys was impaired. Malnourished girls had an impairment of delayed recall of only words. The above study has shown that though there is decrease in full scale IQ, yet performance on all the subtests was not affected. This suggests that malnutrition may affect different neuropsychological functions to different degrees. Studies done in Africa and South America have focused on the effect of stunted growth on cognitive abilities using verbal intelligence tests based on assessment of reasoning (Mendez and Adair, 1999). Such an assessment does not provide a comprehensive and specific assessment of cognitive processes like attention, memory, executive functions, visuo-spatial functions, comprehension as conducted in the present study. Information about the functional status of specific cognitive processes has implications for developing a cognitive rehabilitation program for malnourished children. A neuropsychological assessment would throw light on functional status of brain behaviour relationships affected by malnutrition. Deficits of cognitive, emotional and behavioural functioning are linked to structural abnormalities of different regions of the brain. Brain structures and brain circuits compute different components of cognitive processes (Posner et al.1988). Malnutrition has long lasting effects in the realm of cognition and behaviour, although the cognitive processes like executive functions have not been fully assessed (Levitsky and strup, 1995). A neuropsychological assessment would be able to delineate the pattern of brain dysfunction. Malnutrition is a grave problem in our country as 52% of our children are malnourished. Effects of protein-calorie malnutrition are inextricably blended with the effects of social cultural disadvantage; even within the disadvantaged class, literacy environment at home and parental expectation regarding children's education are powerful variables. Perhaps membership in a higher caste confers some advantage in regard to home literacy, and parental expectation. Short and tall children do differ in some cognitive tests, but not in all as demonstrated in a study done in Orissa, India (Das and Pivato, 1976). But whether or not stunted growth alone is the causative variable for cognitive weakness is not determined as yet. Moreover, the functional integrity of specific cognitive processes is less clear. Chronic PEM resulting in stunting and wasting could result in delay in the development of cognitive processes or in permanent cognitive impairments.

Neuropsychological measures can demonstrate delay in normally developing cognitive processes as well as permanent cognitive deficits.

The present study was an attempt to investigate the effect of stunting (as a result of PEM), BMI, Socioeconomic status, age and sex variation on the rate of cognitive development. Neuropsychological measures, standardized with respect to the age trends of cognitive processes in children in the age range of 5–10 years have been employed which would also inform about the neuropsychological performance of malnourished children.

1.4. Problem statement: The physical growth is an important feature in the lifespan of the children. It may vary from one population to other depending on the genetic, socioeconomic, environmental and other factors. Along with the physical growth, cognitive and motor growth of the children is also important in their life. Neurophysiologic characteristics, e.g., cognitive ability and motor skill may be dependent on several factors. Those influencing factors should be identified for each of the populations because certain factors may be population specific. Secondly every population should have normative data for different characteristics of physical growth as well as cognitive and motor growth. Some data / information are available from different studies in Indian population regarding the physical growth pattern of Indian children but the studies on cognitive and motor growth pattern is scanty. Especially more or less no information is available in the literature about the cognitive and motor growth pattern in Bengali children. There also lack of standard normative data on the said parameters of the Bengali children. This lacuna inspired us to study on neurophysiological growth in response to nutritional status and socioeconomic status and to form the norms for cognitive skill and motor ability parameters of the primary school going children in the Bengali population.

Review of Literature

Chapter II

Contents

Cognitive development refers to the progressive and continuous growth of perception, memory and imagination, conception and judgement and reason; it is the counterpart of one's biological adaptation to environment (Nicolosi et al.1989).Cognition also involves the mental activities of comprehending information and the process of acquiring, organizing, remembering, the using of knowledge (Owens 2008).This knowledge is subsequently used for problem solving and generalization to novel stimulation.

Many theories have been proposed regarding how children learn about their environment and how cognitive development proceeds. The Swiss, developmental psychologist Jean Pieget (1954) viewed the child as an active participant in the learning process. He considered that new learning took place as the child interacted with the environment and the other people. According to the author, cognitive development is based on four factors: Maturation, physical experience, social interaction, general progression towards equilibrium.

Piaget (1954) also outlined four different stages of cognitive development: the sensorimotor stage, the pre-operational stage, the concrete operational stage, and the formal operational stage. Elementary school-age children fall within the pre-operational (ages two to seven) or the concrete operational stage (ages eight to eleven. Pre-operational stage children have not yet developed the ability to think logically. They “deal with the world symbolically, or representationally. That is, they develop the ability to imagine doing something, rather than actually doing it”. In the preoperational stage, children tend to proceed in thought from detail to detail and are unable to generalize. Children in this stage also discover and develop through pretend play. They are able to watch their parents and others around them, and pretend to go shopping or play house. A child in the pre-operational stage is unable to see things from another person's perspective; hence, a child in this stage must experience everything directly because they cannot understand what consequences there may be or think about how another person may react. In the concrete operational stage, children are able to think logically. They begin to understand things from another person's perspective, and understand the ideas of conservation and reversibility. They also develop the ability to classify objects into a series or by hierarchy; however, it is important to understand that children in this stage are unable to think or reason abstractly.

Cognitive skills of young children are an important factor in explaining success later-on in life. Skill attainment at one stage of the life cycle raises skill attainment at later stages of the life cycle (Cunha et al. 2006). Cognitive ability affects the likelihood of acquiring higher education and advanced training, and the economic returns in terms of wages and quality of jobs (Heckman & Masterov, 2007; Cunha et al. 2006).

Cognitive skills are not fixed but can be influenced through investment in preschool training, education in school, and significantly, parental efforts. The most effective period for cognitive skill investment by parents is early on in the life of their children (Cunha et al. 2006).

Research has found that reading story books is one of the most important activities for developing the knowledge required for eventual success in reading. Reading to pre-schoolers has been found to be related to language growth, emergent literacy and reading achievement. (Bus et al. 1995). In addition, reading to children also stimulates them to read books themselves and further develop their cognitive skills (Canoy et al. 2006).

Bloom and Tinker (2001) proposed a model for language development that suggested languages emerge out of complex development in cognition social, emotional development and motor skill.

In the year of 1999 Eccles investigated on child, middle childhood and early adolescence at the age of 6-14 to identify the time of important developmental advances that established children's sense of identity. Eccles showed that during these years, children made strides toward adulthood by becoming competent, independent, self-aware, and involved in the world beyond their families. Biological and cognitive changes transformed children's bodies and minds. Social relationships and roles change dramatically as children entered school, joined programs, and became involved with peers and adults outside their families. During middle childhood, children developed a sense of self-esteem and individuality, comparing themselves with their peers. They came to expect they would succeed or fail at different tasks. They might develop an orientation toward achievement that would colour their response to school and other challenges for many years. In early adolescence, the tumultuous physical and social changes that accompanied puberty, the desire for autonomy and distance from the family, and the transition from elementary school to middle school or junior high could all cause problems for young people. When adolescents were in settings (in school, at home, or in community programs) that were not attuned to their needs and emerging independence, they could lose confidence in themselves and slipped into negative behaviour patterns such as truancy and school dropout. It was concluded that developmental changes that characterized the years from 6 to 14, and it highlighted ways in which the organization of programs, schools, and family life could better support positive outcomes for youths.

Cognitive skills are understood as the mental actions or processes of acquiring knowledge and understanding through thought, experience, and the senses (Devis et al. 2011). Executive functions are described as higher order cognitive skills that enable self-control and include the following metacognitive skills: response inhibition, which is described as the suppression of actions that are no longer required or that are inappropriate; planning, which is described as a plan that can be represented as a hierarchy of sub goals, each requiring actions to achieve the goal; attention, which is described as the ability to attend to some things while ignoring others; and working memory, which is described as the ability to store and manipulate information over a period of seconds to minutes (Gazzaniga et al. 2009). Visual processing is described as a path that information takes from visual sensors to cognitive processing (Boden and Giaschi ,2007) Short-term memory is described as the capacity to hold information in mind in the absence of external stimulation over a short period of time (Nee and Ionides, 2013). Information retained for a significant time is referred to as long-term memory (Gazzaniga et al. 2009). Fluid intelligence is the ability to think logically and solve problems in novel situations; this is independent of acquired knowledge (Catell 1971). Crystallized intelligence refers to the capacity to use skills, knowledge, and experience by accessing information from long-term memory(Catell 1971) Intelligence quotient (IQ) is a measure to calculate a person’s intelligence. Academic skills are skills developed or measured in educational settings.

Piaget’s theory was based on the idea that children learn from observable motor actions with objects. There were several explanations for a possible relationship between motor and cognitive skills in children. Research has shown that co-activations between the prefrontal cortex, the cerebellum, and the basal ganglia during several motor and cognitive tasks, especially when a task is difficult, a task is new, conditions of a task change, a quick response is required, and concentration is needed to perform a task (Desmond et al. 2000; Diamond 2001) A second explanation for a relationship between motor and cognitive skills is that these skills might have a similar developmental timetable with an accelerated development between the ages of 5 and 10 years (Anderson et al. 2000). Both motor and cognitive skills have several common underlying processes, such as sequencing, monitoring, and planning .(Roeber and Kauer ,2009).

Several factors affect the cognitive and motor skills of the children. Some of the important factors are pointed out below.

2.1. Cognitive skill and motor ability of the children in relation to age and gender variation:

Using structural brain imaging Cedric et al. (2013) had demonstrated that brain development continues through childhood and adolescence. In their cross-sectional study, structural MRI data from 442 typically developing individuals (range 8–30) were analyzed to examine and replicate the relationship between age, sex, brain volumes, cortical thickness and surface area. They showed differential patterns for sub cortical and cortical areas. Analysis of sub cortical volumes showed that putamen volume decreased with age and thalamus volume increased with age. Independent of age, males demonstrated larger amygdala and thalamus volumes compared to females. Cerebral white matter increased linearly with age, at a faster pace for females than males. Gray matter showed nonlinear decreases with age. Sex-by-age interactions were primarily established that lobar surface area measurements, with males demonstrating a larger cortical surface up to age 15, while cortical surface in females remained relatively stable with increasing age. In addition, their results pointed out toward an important role for sex differences in brain development, specifically during the heterogeneous developmental phase of puberty. Bellis et al. (2001) investigated on maturation of brain in differentiation of sex demonstrated that development of brain during childhood and adolescence was characterised by both progressive myelination and regressive pruning process. After the use of MRI, they concluded that there was age related reduction in cerebral grey matter and increase white matter volume along with the volume of corpus calosum. They established that intra cranial cerebral volume did not change significantly. It was concluded that male had more prominent age related grey matter decreases and white matter volume and corpus callosal area increases compared to female.

Sex differences in age- and puberty-related maturation of human brain structure have been observed by Bramen et al. (2010). They evaluated sex differences brain structure with 80 adolescence boys and girls. They observed that girls mature 1-2 years earlier than boys. They evaluated pubertal influences on medial temporal lobe (MTL), thalamic, caudate, and cortical gray matter volumes utilizing structural magnetic resonance imaging and 2 measures of pubertal status: physical sexual maturity and circulating testosterone. Significant interactions between sex and the effect of puberty were observed in regions with high sex steroid hormone receptor densities; sex differences in the right hippocampus, bilateral amygdala, and cortical gray matter were greater in more sexually mature adolescents was predicted. Within sex, it was found larger volumes in MTL structures in more sexually mature boys, whereas smaller volumes were observed in more sexually mature girls (Bramen et al. 2010). Results of the study were puberty-related maturation of the hippocampus, amygdala, and cortical gray matter that was not confounded by age, and was different for girls and boys. Age and sex differences were also examined by Gur et al. (2013) by applying a comprehensive computerized battery of identical behavioural measures that linked to brain systems in youths. They showed that substantial improvement with age occurred for both accuracy and speed, but the rates varied by domain. The most pronounced improvement was noted in executive control functions, specifically attention, and in motor speed. They observed that least pronounced age group effect was in memory, where only face memory showed a large effect size on improved accuracy. It was noted that sex differences had much smaller effect sizes but were evident, with females outperforming males on attention, word and face memory, reasoning speed and all social cognition tests. Males outperform females in spatial processing and sensorimotor and motor speed. These sex differences in most domains were seen already at the youngest age groups, and age group × sex interactions indicated divergence at the oldest groups with females becoming faster but less accurate than males. It was concluded that cognitive performance improves substantially in this age span, with large effect sizes that differ by domain. The more pronounced improvement for executive and reasoning domains than for memory suggests that memory capacities have reached their apex before age 8 (Gur et al. 2013). Performance was sexually modulated and most sex differences were apparent by early adolescence.

Gender differences in the latent cognitive abilities underlying the Wechsler Primary and Preschool Scale of Intelligence (WPPSI-IV) were investigated by Palejwala and Fine, (2014) in children aged 2 to 7 years. They analysed the multiple-group confirmatory factor that was used to verify the measurement invariance of the WPPSI-IV factor model in boys and girls. The magnitude of gender differences in the means and variances of the abilities was estimated. It was proposed that girls aged 2 to 7 years had higher general intelligence and girls aged 4 to 7 years demonstrated an advantage in processing speed. They showed that a gender difference favouring boys in visual processing was absent in ages 2 to 3 but emerged in ages 4 to 7 years. It was stated that gender differences in fluid reasoning, short-term memory, and comprehension-knowledge were not found. The variability of any of the abilities did not differ among girls and boys. These results indicated that gender differences in cognitive abilities emerged in early childhood, which might contribute to gender differences in later educational outcomes.

Recently Flatters et al. (2014) investigated that age and sex-differences in the ability of 422 children to control a handheld stylus. A task battery was deployed using tablet PC technology presented interactive visual targets on a computer screen whilst simultaneously recording participant’s objective kinematic responses, via their interactions with the on-screen stimuli using the handheld stylus. The tasks were not familiar to the children, allowing measurement of a general ability that might be meaningfully labelled ‘manual control’, whilst minimising culturally determined differences in experience (as much as possible). They found that a reliable interaction between sex and age on the aiming task. It was reported those movement times of girls being faster than boys in younger age groups (e.g. 4–5 years) but with this pattern reversing in older children (10–11 years). They concluded that improved performance in older boys on the aiming task was consistent with prior evidence of a male advantage for gross-motor aiming tasks, which begins to emerge during adolescence. A small but reliable sex difference was found in tracing skill, with girls showing a slightly higher level of performance than boys irrespective of age. Overall, their findings suggested that prepubescent girls were more likely to have superior manual control abilities for performing novel tasks.

To examine the effect of gender on regional brain activity, Bell et al. (2006) investigated the functional magnetic resonance imaging (fMRI) during a motor task and three cognitive tasks- such as word generation task, a spatial attention task, and a working memory task in healthy male (n = 23) and female (n = 10) volunteers. Functional data were analysed for group differences both in the number of pixels activated and the blood–oxygen-level-dependent (BOLD) magnitude during each task. From the experiment it was shown that males had a significantly greater mean activation compared to that of females in the working memory task with a greater number of pixels being activated in the right superior parietal gyrus and right inferior occipital gyrus. It was also showed that greater BOLD magnitude occurring in the left inferior parietal lobe. However, it was reported that despite these fMRI changes, there were no significant differences between males and females on cognitive performance of the task were found. In contrast, in the spatial attention task, men performed better at this task than women. In the word generation task, males had a significantly greater mean activation than females, where males had a significantly greater BOLD signal magnitude in the left and right dorsolateral prefrontal cortex, the right inferior parietal lobe, and the cingulate was reported. They also reported that during the motor tasks, greater mean BOLD signal magnitude in males in the right hand motor task, compared to females where males had an increased BOLD signal magnitude in the right inferior parietal gyrus and in the left inferior frontal gyrus. Differential patterns of activation in males and females during a variety of cognitive tasks, even though performance in these tasks may not vary, and also that variability in performance may not be reflected in differences in brain activation was concluded.

A study was conducted by Vlachos et al. (2014) on 300 hundred children(154 boys and 146 girls) at the age group 60-71 month that were divided into two age subgroup (60-65 and 66-71). They were examined in three motor task such as bead threading, shape coping and postural stability, and visuomotor, graphomotor, and balance skill respectively. They showed a significant effect of age in graphomotor task. Performances of older children were better than younger was established. It was pointed out that performances of girls were significantly better than boys in visuomotor and graphomotor task. They also showed that boys outperformed the girls on balance task.

2.2.Nutrition and Cognitive skill

Relationships between nutrition and cognitive function of the brain have been the focus of much research. Studies have shown the impact of dietary foundations on normal brain functions. Chemical messengers within the brain called neurotransmitters have been studied in conjunction with nutrition. Growden and Wurtman, (1980) suggested that the brain could no longer be viewed as an autonomous organ, free from other metabolic processes in the body; instead, the brain needed to be seen as being affected by nutrition, the concentration of amino acids and choline (in the blood) which let the brain create and use many of its neurotransmitters such as serotonin, acetylcholine, dopamine, and norepinephrine. Food consumption is vital to the brain being able to make the right amount of amino acids and choline. These are two precursor molecules obtained from the blood that are needed for the brain to function normally. It is of no surprise that what we eat directly influences the brain (Colby-Morley 1981).

Wood and kretsch et al. (2001) showed that nutrition has a role with affecting cognitive functioning. Studies have been done with school-aged children and point to a direct correlation between poor nutrition and lowered school performance.

Erickson (2006) pointed out five key components, based on research, required to keep the brain functioning correctly. The substances, all found in food, were important to brain development and function. Proteins are found in foods such as meat, fish, milk, and cheese. They were used to make most of the body's tissues, including neurotransmitters, earlier identified as chemical messengers that carry information from brain cells to other brain cells. A lack of protein, also known as Protein Energy Malnutrition, led to poor school performance by children and caused young children to be lethargic, withdrawn, and passive, all of which affect social and emotional development.

Carbohydrates are commonly found in grains, fruits, and vegetables. Carbohydrates are broken down into glucose (sugar) which is where the brain gets its energy. Fluctuating levels of carbohydrates may cause dizziness and mental confusion, both of which can affect cognitive performance. Eating a carbohydrate-heavy meal can cause one to feel more calm and relaxed because of a brain chemical called serotonin and its effect on mood. Serotonin is created within the brain through the absorption and conversion of tryptophan. Tryptophan is absorbed within the blood and this absorption is enhanced with carbohydrates (Erickson 2006). Erickson also noted that fat made up more than 60% of the brain and acted as a messenger in partial control of aspects such as mood. Omega-3 fatty acids were very important to the optimum performance of the brain and a lack of these fats could lead to depression, poor memory, low IQ, learning disabilities, and dyslexia. Important foods to consume to ensure an Omega-3 fatty acid diet were certain fish and nuts.

Wolpert and Wheeler, (2008) cited research done by Gomez-Pinilla, a UCLA professor of neurosurgery and physiological science. According to the article, diet, exercise, and sleep had the potential to alter brain health and mental function. Gomez-Pinilla stated that it stood to reason that changes in diet could be used to enhance cognitive abilities. His research had shown that Omega-3 fatty acids such as those found in salmon, kiwi fruit, and walnuts, provided many benefits in improving memory and learning, much of which occurs at the synapses. Omega-3 fatty acids support synaptic plasticity and seem to positively affect the expression of several molecules related to learning and memory that were found on the synapses. Omega-3 fatty acids were essential for normal brain function. The article stated that a deficiency in Omega-3 fatty acids could lead to increased risk of attention-deficit disorder and dyslexia. According to Gomez-Pinilla, children who had an increase of Omega-3 fatty acids performed better in reading, spelling, and had fewer behavioral problems. Omega-3 fatty acids along with other nutrients like iron, zinc, folic acid and vitamins A, B6, B12, and C. These students showed higher scores on tests measuring verbal intelligence, learning skills, and memory after six months and one year as compared to a control group of students who did not receive the drink (Wolpert & Wheeler, 2008). In the article of Wolpert and Wheeler, Gomez-Pinilla suggested that diets high in trans-fats and saturated fats negatively affected cognition. These trans-fats are found in common fast food and most junk foods. Through these trans-fats, junk food affects the brain synapses as well as many molecules that aid in learning and memory. A diet low in trans-fats and high in Omega-3 fatty acids could strengthen synapses and provide cognitive benefits.

Wolfe and Burkman, (2000) pointed out that confirmed proper nutritional support was important to allow the brain to function at its highest ability and to enhance learning. Wolf and Burkman, (2000) suggested that it didn’t take much complication or obscurity through expensive foods and supplements to help students reach their potentials; healthful nutritional habits learned early in life help endure normal physiological and neurological growth and development, which translated into students’ achieving optimal learning, defined as the abilities to recall information, to problem solve, and to think critically. The authors mentioned several dietary components that supported brain function and neurotransmitter activity, and also recommend a wide range of foods as nutrient sources; the most important were protein, fat, B vitamins, iron, chlone and antioxidants. Offering students the right food choices and helping them to develop positive, healthy eating habits would support optimal functioning of the brain. Lahey and Rosen, (2010) concluded from the research that nutrition affected learning and behavior and they suggested that diet could influence cognition and behavior in many ways, which included the condition of not enough nutrition or the condition of the lack of certain nutrients. About one-third of children who completed a food-habit questionnaire had inadequate fruit and vegetable intake. These students also showed poor school performance as compared to those students who had an adequate intake of fruits and vegetables.

Zhang et al. (2005) looked specifically at fats in the American diet, as the customary diet of American children and adults was high in total fat, saturated fat, and cholesterol. The authors sought to identify associations with fat intake and psychosocial and cognitive functioning in U.S. school-aged children, since it had been unclear whether and how specific fats might affect social and cognitive development. Data was used from the Third National Health and Nutrition Examination Survey (NHANES III). Medical and cognitive examinations and interviews were conducted with children and proxy respondents. A total of 5,367 children aged 6-16 participated in the Household Youth Interview. After attrition, a total of 3,666 children remained for the analyses. Mothers were asked a series of questions concerning their children's behaviors and social skills. Children were administered the Arithmetic and Reading Subtests of the Wide Range Achievement Test, Revised (WRAT-R) and the block design and digit span subtests of the Wechsler Intelligence Scale for Children, Revised (WISC-R). The WRAT-R arithmetic subtest consists of oral and written problems ranging from addition to calculus, and the Reading subtest assesses letter recognition and word reading skills. A twenty-four hour diet recall interview was administered to the proxies of the children in the study using a trained dietary interviewer using the Dietary Data Collection System designed to probe for fat and salt used in the preparation of foods. It was noted that individuals with a high intake of polyunsaturated fatty acids (PUFAs) had a lower proportion of poor reading performance but a higher proportion of reported difficulties in getting along with peers. However, increasing or decreasing total fat or saturated fat was not associated with cognitive functioning.

Ambaw (2013) showed the effect of mild to moderate chronic malnutrition on cognitive development, fifty three children of age 29-42.5 months were studied from May-June, 2011 in Jimma town, Ethiopia. Cognitive development was measured in Bayley scales-III, and nutritional assessment was done using anthropometric measurements. Ambaw concluded that mild to moderate stunting was associated with lower cognitive level. Mild and moderate malnutrition can have a significant negative effect on cognitive development.

Kulkarni et al. (2014) assessed that the gross motor development in infants with protein energy malnutrition (PEM) using AIMS. They made a cross-sectional study that conducted on 200 infants of age 6 to 18 months with PEM. They recorded their baseline information and the gross motor development of the infants was assessed in four different positions, i.e., supine, prone, sitting and standing. They observed score as per the movements of the infant observed and summated the sub-score in all the positions to get the total score and calculated them in a percentile rank. It was shown that 74% infants belonged to < 10th percentile rank of AIMS indicating atypical motor performance and 19% infants belonged to < 25th percentile rank indicating suspected motor performance with statistical significance of $p < 0.001$. The results of their study concluded that on assessment with AIMS , infants of age 6 to 18 months with Protein Energy Malnutrition showed lower motor performance signifying delayed gross motor development.

2.2.1. Effect of Vitamins and minerals on cognitive and motor abilities :

Erickson (2006) discussed vitamins and minerals as an important substance for the functioning of the brain. Most important were the vitamins A, C, E, and B complex vitamins. Manganese and magnesium were two minerals essential for brain functioning; sodium, potassium and calcium played a role in message transmission and the thinking process. Neurotransmitters were crucial to brain function in the transferring of messages. Erickson stated that the nutrition was an important to the production of key neurotransmitters such as acetylcholine, dopamine, and serotonin.

Iron has also been shown to play an important role in brain function as well. Kretsch et al. (2001) cited details from a study done with men aged 27 to 47 yrs that looked at iron and its effect on concentration. Low scores on a concentration test corresponded with lowered levels of iron in the bodies of the subjects. A connection was made between low iron levels in children with attention span; children with iron deficiency anemia have been shown to have short attention spans. Kretsch et al. also found that zinc was another nutrient that had a role with cognition, specifically with memory. In a test of mental function called verbal memory, scientists found that volunteers' abilities to remember everyday words slowed significantly only after three weeks of a low-zinc diet (Wood 2001).

In 2006, Hamadani et al. assessed the effect of zinc supplementation on the developmental levels and behaviour of Bangladeshi infants. This was a randomized, double-blind, controlled trial conducted in Dhaka, Bangladesh. Three hundred one infants aged 1 month were randomly assigned to receive either 5 mg elemental Zn or placebo daily for 5 month, and subsequent growth and morbidity were observed. For the that study, developmental levels were assessed in a subsample of 212 infants at 7 and 13 month of age with use of the Bayley Scales of Infant development, and they observed the infants' behaviour during the tests. The children's social backgrounds, weights, and lengths were also recorded. The mental development index scores of the zinc treated group were slightly but significantly lower than those of the placebo group. That finding might have been due to micronutrient imbalance.

Gamblling et al. (2008) focused on the effect of iron, copper and their interaction on the development, they concluded that copper and iron were essential for normal fetal development. Maternal copper and/or iron deficiency during pregnancy had serious consequences for the offspring. These range from direct effects of a decreased enzyme activity to indirect results of changed activities of signaling pathways. Although most data have been obtained in animal models, the extreme examples of Menkes disease and the milder effects of maternal iron deficiency on infant cognitive ability provided strong supporting evidence for humans being equally vulnerable. It has been clearly established that deficiencies of either iron or copper alter the distribution of the other mineral, although the mechanisms are not yet understood. However, given the high incidence of maternal anemia during pregnancy, and that many women who were prescribed iron supplements shown significant improvement, it was tempting to conclude that at least some of the cases were as a consequence of low copper. Deficiency of iron has been shown to affect cognitive and motor development in the critical prenatal and early childhood periods by altering interactive morphological, neurochemical, and bioenergetic processes such as oligodendrocyte wrapping for myelination, monoamine synthesis in the striatum influencing dopamine metabolism, and neuronal and glial energy metabolism in the hippocampus. Similarly, zinc deficiency may deter development by affecting activity in 200 enzymes related to RNA and DNA synthesis, NMDA receptor regulation in the hippocampus, and other structural and functional mechanisms in the brain. It was also suggested by Trans and his associates (2008) that deficiency of iron that caused down regulated brain-derived neurotrophic factor (BDNF) expression in the hippocampus without compensatory up regulation of its specific receptor, tyrosine-receptor kinase B. Consistent with low overall BDNF activity, they found lower expression of early-growth response gene-1 and 2, transcriptional targets of BDNF signaling. Doublecortin expression, a marker of differentiating neurons, was reduced during peak iron deficiency, suggesting impaired neuronal differentiation in the ID hippocampus. In contrast, iron deficiency up regulated hippocampal nerve growth factor, epidermal growth factor, and glial-derived neurotrophic factor accompanied by an increase in neurotrophic receptor p75 expression.

Their findings suggested that fetal-neonatal iron deficiency lowered BDNF function and impaired neuronal differentiation in the hippocampus. Neurotransmitter is an important chemical substance that responsible for conduction of neuronal signal through the synapse. Iron plays important roles in neurotransmitter synthesis. In 2009, scientist Coe showed in his studies that deficiency of iron caused decrement of monoamine neurotransmitters and level of dopamine was significantly higher than the norepinephrine levels. These findings indicated that ID could affect the developmental trajectory of these two important neurotransmitter systems, which were associated with emotionality and behavioral performance, and further that the impact in the young monkey was most evident during the period of recovery.

Interrelation between iron, zinc and folic acid on cognitive and motor skill has been focused by Christian et al. (2012). They concluded that maternal iron-folic acid supplementation appeared to add little benefit for combating the deleterious effects of micronutrient deficiency on intelligence, executive function, and motor development. Fortunately, fewer risks and logistical barriers were involved in maternal iron-folic acid supplementation than combined maternal and child supplementation.

In the year 2008 the scientist Youdim studied the effect of iron deficiency and excess on cognitive impairment and neural changes in striatum and hippocampus and demonstrated impairment of learning in young school children with iron deficiency. Indeed, rats made iron deficient have lowered brain iron and impaired behaviors including learning. This could become irreversible especially in newborns, even after long-term iron supplementation. In this condition the brain striatal dopaminergic-opiate system which became defective, resulting in alterations in circadian behaviors, cognitive impairment and neurochemical changes closely associated with them. The investigators had extended these studies and established that cognitive impairment may be closely associated with neuroanatomical damage and zinc metabolism in the hippocampus due to iron deficiency, and which may result from abnormal cholinergic function. The hippocampus is the focus of many studies today, since this brain structure has high zinc concentration and is highly involved in many forms of cognitive deficits as a consequence of cholinergic deficiency and has achieved prominence because of dementia in ageing and Alzheimer's disease. Thus, it was apparent that cognitive impairment may not be attributed to a single neurotransmitter, but rather, alterations and interactions of several systems in different brain regions. In animal models of iron deficiency it was apparent that dopaminergic interaction with the opiate system and cholinergic neurotransmission may be defective.

Sen et al. (2009) investigated that the impact of iron and folic acid supplementation on cognitive abilities in school girls aged between 9 and 13 years in vadodara. They showed significant improvement in the various cognitive tests. The benefits were greater in anaemic subjects, those with higher haemoglobin increments and with better compliance, and with increasing frequency of supplementation. They concluded that the iron supplementation caused an improvement in cognition in older children, especially those who were anaemic.

2.3. Physical growth and cognitive and motor development:

WHO multicare growth reference study group (2006) investigated the relationships among physical growth indicators and ages of achievement of six gross motor milestones in the WHO Child Growth Standards population. Gross motor development assessments were performed longitudinally on the 816 children included in the WHO Child Growth Standards. They observed that there were significant associations between gross motor development and some physical growth indicators, but these were quantitatively of limited practical significance. Their results suggested that in healthy populations, the attainment of these six gross motor milestones was largely independent of variations in physical growth.

Kar et al. (2008) examined the effect of stunted growth on the nature of cognitive impairments and on the rate of cognitive development. The participants were identified as being malnourished or adequately nourished in the age groups of five- to seven-year olds and eight- to ten-year olds. Students in the malnourished group were identified by their height (stunting) and weight (wasting) of children in the same age categories with reference to the national center of health statistics (NCHS). The test they were given was the NIMHANS neuropsychological battery for children. It was developed for children aged five to fifteen. The battery consists of neuropsychological tests to assess motor speed, attention, executive function, visuospatial relationships, comprehension, learning, and memory. Each section was grouped under a specific cognitive domain on the basis of theoretical rationale and factor analysis. They compared the performance of adequately nourished children to malnourished children and also compared age related differences in cognitive function and found that the malnourished children differed from the adequately nourished children on tests of phonemic fluency, design fluency, selective attention, visuospatial working memory, visuospatial functions, verbal comprehension and verbal learning, and memory. Results for the verbal fluency test show adequately-nourished children achieved higher mean scores in both age categories, five- to seven- year olds and eight- to ten- year olds (4.3 and 5.7 respectively), when compared to their malnourished counterparts (1.36 and 4.4 respectively). Some of the other results had similar findings such as, visual construction in adequately nourished in both age categories (10.0 and 15.8) scores were higher than malnourished students (3.0 and 4.8) in the same age categories and also for verbal learning (32.4 and 42.3 vs. 26.9 and 30.7). These results showed age related differences within each group as well as between the two age groups. Kar et al. also found a lack of age-related improvement in malnourished children when looking at cognitive functions of attention, cognitive flexibility, visuospatial construction, ability and verbal learning. Malnourished students showed lower results than the adequately nourished students but they did show age related improvement for these same functions. Differences were tested for statistical significance. Test scores for adequately nourished children between 5- to 7- years old and 8- to 10- year olds were found significant but most of the test scores for undernourished children showed a delay in development of certain cognitive functions. These findings should be retested with a larger sample of participants to see if the trend was consistent with not only malnourished and adequately nourished children but those who were obese from an unhealthy diet.

Li et al. (2008) examined the associations between academic performance, cognitive functioning, and increased BMI. They studied a nationally representative sample of 2,519 children ages eight to sixteen years old. Each participant had completed a brief neuropsychological battery and measures of height and weight. Trained examiners administered tests in a standardized environment using uniform procedures. Each participant was then categorized to an overweight BMI, an at-risk BMI, or a normal BMI. Blood pressure, cholesterol, serum triglycerides levels, and iron deficiency were also observed. Iron deficiency has been known to be associated with poor cognitive function, and a high occurrence of iron deficiency was observed among overweight and obese children and adolescents. Among the subjects 20.33% were classified as overweight and 15.92% were obese. The association between BMI, cognitive functioning, and academic performance was noted. Test scores decreased as BMI on increased. The block design test had the greatest discrepancy among participants with 5.04% of normal weight children scoring poorly, 9.19% of at-risk children scoring poorly, and 12.18%

of obese children scoring poorly. Test scores were defined as poor when they were less than 2 standard deviations from the mean. The odds of poor performance in visuospatial organization and general mental ability were doubled among at-risk children and tripled among overweight children when compared to normal weight children. From the results it was observed that being overweight was not the root cause of poor academic performance but found that obese adolescents consider themselves worse students. Another result from the study was that decreased cognitive function was associated with increased weight status. Cognitive deficits on tests of motor speed, weakened performance on motor speed and manual dexterity, and executive function were found. Poor performance on memory tasks was also common among obese people. Those with poorer cognitive ability may do worse in school and opt for a lifestyle that promotes weight gain. This study verified that this association may exist among overweight children or children at-risk of being overweight without clinically diagnosed diabetes mellitus, vascular disease, or cardiac disease that often characterize adult patients. It was also found a relationship with decreased block design and weight. Block design is a measure of visuospatial organization and general mental ability which has been shown to be sensitive to brain damage. Results showed that the unfavorable effects of increased body weight on cognitive function start showing as early as childhood. Cognitive function decline may occur in younger persons and findings show an increase body weight worsened other risks factors for cardiovascular disease as time passes. One of the most concerning outcomes of iron deficiency in children was the change of behavior and cognitive performance.

Casale et al. (2014) evaluated effects of stunting in childhood by exploring the links between linear growth retardation and measures of development among preschool-aged children. They analysed the association between stunting (height-for-age z-score <−2) at age 2 years and children's scores on the Vineland Social Maturity Scale (VSMS) at age 4 years, and the measure of social competence or 'daily living skills', and the Revised-Denver Pre-screening Developmental Questionnaire (R-DPDQ) at age 5 years, a test which places greater emphasis on cognitive functioning.. They conducted multivariate regression analysis controlling for socio-economic status, various child-specific characteristics, home environment and caregiver inputs. No significant association was found in between stunting and children's performance on the VSMS, but a large and significant association with the R-DPDQ scores, was found. A disaggregated analysis of the various components of the scores suggested that children with low height-for-age at 2 years did not fall behind in terms of daily living skills or social maturity, but did substantially worse on measures capturing higher order fine motor skills and cognitive functioning. It was concluded that stunting in early childhood is strongly related to impaired cognitive functioning in children of preschool age.

Chang et al. (2010) investigated on the effects of early childhood stunting (height for age 2SD or more below reference values) and interventions on fine motor abilities at 11 to 12 years, and the relationship between fine motor abilities and school achievement and intelligence. For that study a cohort of stunted was compared with a group of non-stunted children. Fine motor abilities were assessed in 116 stunted (67 males, 49 females) and 80 non-stunted children (43 males, 37 females) at a mean age of 11 years 8 months and 11 years 9 months respectively. Testers were blind to the children's group assignment. It was observed that the two fine motor factors and rapid sequential continuous movements (RSCM) and dexterity. They found that the RSCM scores were lower in the stunted group than in the non-stunted group but differences in dexterity were not significant after adjusting for social background. Among stunted children, the RSCM score was significantly associated with IQ and school achievement. Stunting in early childhood was associated with poor scores on tests of rapid sequential continuous hand movements in later childhood. Children with poorer scores were at greater risk for low IQs and low levels of school achievement

Le Thuc Duc (2009) investigated the effect of early age stunting on cognitive achievement among the children in Vietnam. This study was conducted in Vietnam with 2000 children of five province of Vietnam. Their conclusion was that height-for-age z-score, had negative effects on child cognitive development. The impact of early age stunting on cognitive achievement was found to be independent of the source of the variation in HAZ, whether it was due to differences in birth weight and environmental factors, or to household characteristics. The effect of HAZ on cognitive achievement was estimated independent of the influences of the parents' innate mental ability and home environment from the birth of the childhood. The effect of stunting on both verbal and quantitative cognitive achievement was statistically significant. They found out the effect of wealth index on child cognitive achievement to be statistically insignificant. With a multidimensional conception of poverty that includes measures such as nutrition, parental education, household wealth and other factors, the way that poverty was transmitted across generations became clearer than the (one-dimension, monetary only) conception of poverty. Their study also pointed out the other causes of an intergenerational poverty trap, such as living in a poor community with characteristics such as poor infrastructure, isolation and lack of income variety. Such characteristics made a difference to the cognitive development of the child.

2.4 .Socioeconomic status and cognitive and motor skills:

Handal et al. (2007) described the socio demographic and nutritional characteristics associated with neurobehavioral development among young children living in three communities in the north eastern Andean region of Cayambe-abacundo, Ecuador. The Ages and Stages Questionnaire (ASQ) was directly administered to 283 children by two trained interviewers. Growth measurements and haemoglobin estimation was done. Prevalence of developmental delay was calculated, and associations between child development and maternal, child, and household characteristics were explored. They observed high frequencies of developmental delay. Children 3 to 23 months old displayed delay in gross motor skills and children 48 to 61 months old displayed delay in problem-solving skills and fine motor skills. A high frequency of both anaemia (60.4%) and stunting (53.4%) was observed for all age groups. Maternal educational level was positively associated with communication and problem-solving skills, and monthly household income was positively associated with communication, gross motor, and problem-solving skills. The results suggested a high prevalence of developmental delay and poor child health in that population.

Luby et al. (2013) investigated whether the income-to-needs ratio experienced in early childhood impacts brain development at school age and to explore the mediators of this effect. This study was conducted at an academic research unit at the Washington University School of Medicine in St Louis. Data from a prospective longitudinal study of emotion development in preschool children who participated in neuro-imaging at school age were used to investigate the effects of poverty on brain development. Children were assessed annually for 3 to 6 years prior to the time of a magnetic resonance imaging scan, during which they were evaluated on psychosocial, behavioural, and other developmental dimensions. Preschoolers included in the study were 3 to 6 years of age and were recruited from primary care and day care sites in the St Louis metropolitan area; they were annually assessed behaviourally for 5 to 10 years. Healthy preschoolers and those with clinical symptoms of depression participated in neuroimaging at school age/early adolescence. Brain volumes of children's white matter and cortical gray matter, as well as hippocampus and amygdala volumes, that was obtained using magnetic resonance imaging. Mediators of interest were caregiver support/hostility measured observationally during the preschool period and stressful life events measured prospectively. They showed that poverty was associated with smaller white and cortical gray matter and hippocampal and amygdala volumes. The effects of poverty on hippocampal volume were mediated by care giving support/hostility on the left and right, as well as stressful life events on the left. They concluded that the exposure to poverty in early childhood materially impacts brain development at school age further underscores the importance of attention to the well-established deleterious effects of poverty on child development. Effects on the hippocampus were mediated by care giving and stressful life. They also showed poverty had negative effect on child brain development.

Hair et al. (2015) investigated the relationship between household poverty and impaired academic performance. For that Longitudinal cohort study analyzing the 823 magnetic resonance imaging scans of 389 typically developing children and adolescents aged 4 to 22 years from the National Institutes of Health Magnetic Resonance Imaging Study of normal brain development with complete socio-demographic and neuro-imaging data. The assessment of the score of children's cognitive and academic achievement and brain tissue, including gray matter of the total brain, frontal lobe, temporal lobe, and hippocampus was made. Poverty was tied to structural differences in several areas of the brain associated with school readiness skills, with the largest influence observed among children from the poorest households. Regional gray matter volumes of children below 1.5 times the federal poverty level were 3 to 4 percentage points below the developmental norm. A larger gap of 8 to 10 percentage points they observed for children below the federal poverty level. Those developmental differences had consequences for children's academic achievement. On average, children from low-income households scored 4 to 7 points lower on standardized tests. As much as 20% of the gap in test scores could be explained by maturational lags in the frontal and temporal lobes. Their conclusion was the influence of poverty on children's learning and achievement was mediated by structural brain development.

Park et al. (2007) find out the cognitive function of homeless children and homelessness might be hypothesized to carry many risks for the developing mind and brain. They wanted to discover whether that hypothesis had been tested previously. Main outcome appeared when formal assessments of cognition were done. As they compared with homeless children with domiciled children, those children who were homeless showed lower intellectual functioning and decreased academic achievement. Furthermore, adolescents evinced cognitive impairments in the contexts of drug, physical, and sexual abuse. They suggested that cognitive and mental health screening be incorporated into those intervention programs deployed to facilitate societal reintegration of homeless children and adolescents.

Noble et al. (2005) also assessed neuro-cognitive functioning of kindergarteners from different socioeconomic backgrounds, using tasks drawn from the cognitive neuroscience literature in order to determine how childhood SES predicts the normal variance in performance across different neurocognitive systems. They examined five neurocognitive systems: the occipitotemporal /visual cognition system, the parietal /spatial cognition system, the medial temporal/memory system, the left perisylvian /language system, and the prefrontal /executive system. They concluded that the SES was disproportionately associated with the last two, with low SES children performing worse than middle SES children on most measures of these systems. Relations among language, executive function, SES and specific aspects of early childhood experience were explored, revealing inter correlations and a seemingly predominant role of individual differences in language ability involved in SES associations with executive function.

Josiane engel et al. (2008) evaluated the impact of socio-economic factors on children's performance on tests of working memory and vocabulary. For this study participation of 20 Brazilian children, of aged 6 and 7 years from low-income families, completed tests of working memory (verbal short-term memory and verbal complex span) and vocabulary (expressive and receptive). A further group of Brazilian children from families of higher socio-economic status matched for age, sex, and nonverbal ability was performed. They showed that children from the low socio-economic group obtained significantly lower scores on measures of expressive and receptive vocabulary than their higher income peers but no significant group differences were found on the working memory measures. They suggested that working memory provided assessments of cognitive abilities that appear to be impervious to substantial differences in socio-economic background. Similar studies were performed by Hook et al. (2013) who investigated the effect of socioeconomic status on development of executive function of brain. They suggested that there was a clear association between childhood socioeconomic status and executive function performance. That association appeared to be mediated by aspects of the family environment, particularly factors involving the quality of the parent-child relationship and its ability to buffer stress. Socioeconomic status-related differences in executive function and brain function did not in any way imply that these differences were innate or unchangeable the hoped that elucidating socioeconomic status effects on cognitive development will allow interventions to target more specific cognitive processes and environmental factors that affect the brain development.

Jeddnorog et al. (2012) systematically explored the association between SES and brain anatomy through MRI in a group of 23 healthy 10-year-old children with a wide range of parental SES. They confirmed behaviourally that language was one of the cognitive domains most affected by SES. Furthermore, they observed widespread modifications in children's brain structure. A lower SES was associated with smaller volumes of gray matter in bilateral hippocampi, middle temporal gyri, left fusiform and right inferior occipito-temporal gyri, according to both volume- and surface-based morphometry. Moreover, they identified local gyrification effects in anterior frontal regions, supportive of a potential developmental lag in lower SES children. In contrast, they found no significant association between SES and white matter architecture. These findings point to the potential neural mediators of the link between unfavourable environmental conditions and cognitive skills.

Mollborn et al. (2013) showed the relationship between socioeconomic status (SES) and child development within the period of early childhood. Longitudinal Study-Birth Cohort (2001–2007), they followed 8600 children from infancy through kindergarten entry to model change over time in the relationship between socioeconomic status and cognitive and behavioural development. The unexpected main finding was that the relationships between three socioeconomic measures (household income, assets, and maternal educational attainment) strengthened from infancy through age 4 or 4½, and then weakened slightly until the start of kindergarten. Indirect evidence suggested that preschool education might be an explanation. They argued for researchers to expand the school transition to include the now nearly universal prekindergarten year, as well as for attention to psychological and physiological developmental factors that may shape the relationship between SES and cognitive and behavioural development throughout early childhood.

The socioeconomic status and brain development was investigated Bradlay et al. (2002). They suggested that (SES) was one of the most widely studied constructs in the social sciences. Several ways of measuring SES have been proposed, but most include some quantification of family income, parental education, and occupational status. Research shows that SES was associated with a wide array of health, cognitive, and socio-emotional outcomes in children, with effects beginning prior to birth and continuing into adulthood. A variety of mechanisms linking SES to child well-being have been proposed, with most involving differences in access to material and social resources or reactions to stress-inducing conditions by both the children themselves and their parents. For children, SES impacts well-being at multiple levels, including both family and neighbourhood. Its effects were moderated by children's own characteristics, family characteristics, and external support systems.

From the above discussion it was appeared that the most of the studies were conducted on the various parameters of cognitive and motor abilities of the children in relation to different influencing factors like, age, gender, physical growth, nutrient intake and socioeconomic characteristics. Many investigators studied the neurological basis of such variation of cognitive and motor characteristics. However, it was noteworthy that major studies cited above have been conducted in abroad. Very little studies in this regard were carried on Indian children. Almost no study was found in the literature which has been conducted on Bengali population in India. In order to fulfill these lacunae, in the present investigation, some efforts have been given to evaluate the cognitive skill and motor ability of primary school children of Bengali population in India.

Aim & Objectives

Chapter III

Contents

3.Aims and objectives of the study

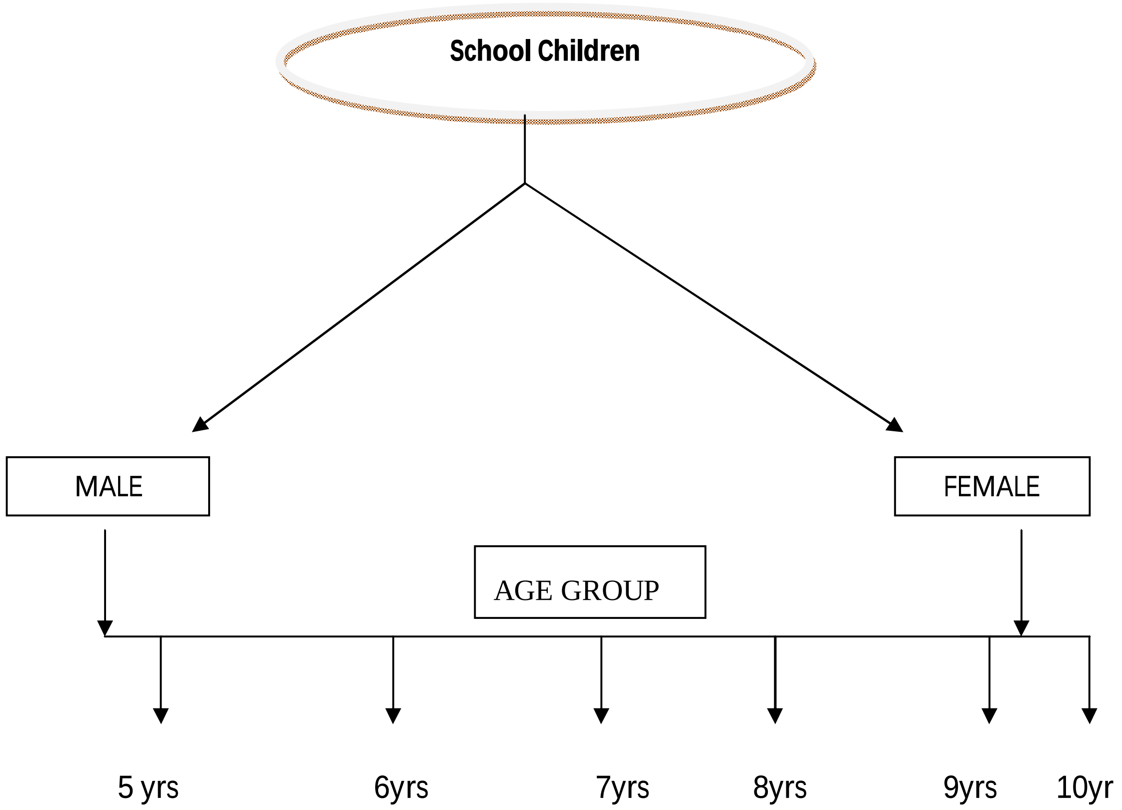
The study was aimed to assess the cognitive skill and motor ability of Bengali boys and girls of primary school level.

The followings are the main objective of the study:

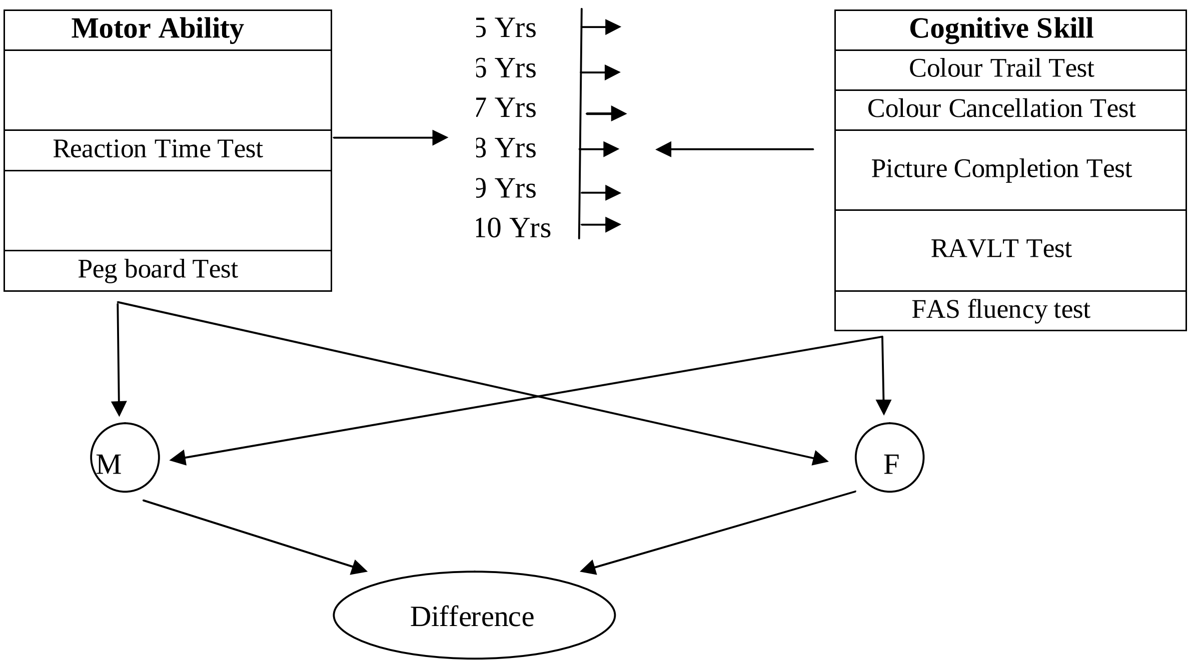
1. To evaluate the motor ability and cognitive skill of primary school children of Bengali population
2. To evaluate physical growth and nutritional status of the primary school children
3. To assess age and gender related changes of motor ability and cognitive skill among primary school children.
4. To find possible association between physical growth and cognitive skill as well as motor ability of primary school children
5. To find possible association of cognitive skill and motor ability of primary school children with nutritional as well as socioeconomic status
6. To find the norms for grading the cognitive skill and motor ability scores of primary school children of Bengali population.

3.1.EXPERIMENTAL DESIGN

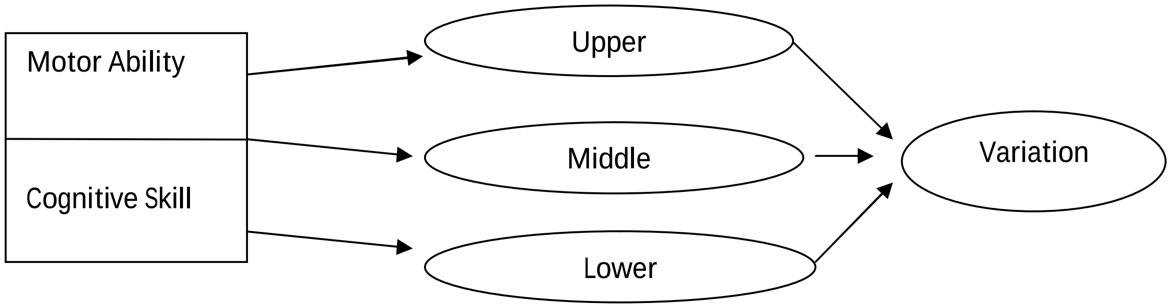
***Phase 1*.GROUPING OF SUBJECT**



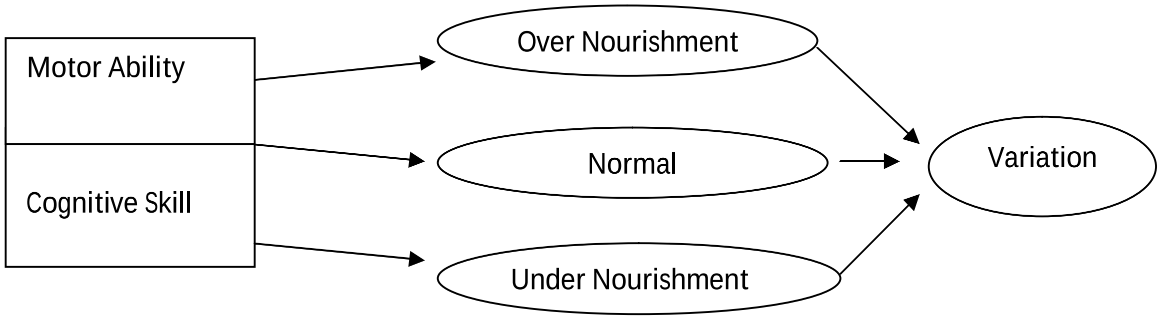
***Phase 2* .AGE AND GENDER VARIATION :**



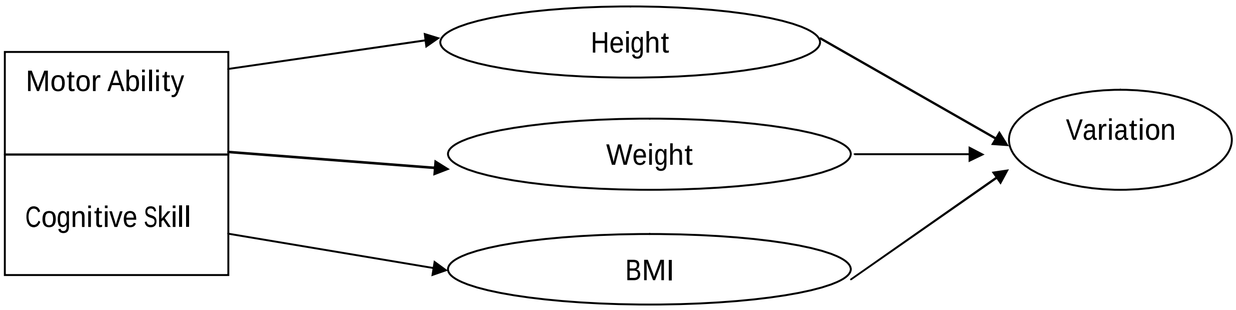
***Phase 3*: VARIATION WITH SOCIO ECONOMIC STATUS:**



***Phase 4*: VARIATION WITH NUTRITIONAL STATUS :**



***Phase 5*: VARIATION WITH PHYSICAL GROWTH:**



Methodology

Chapter IV

Contents

4.1 Selection of Site and Subjects:

The present investigation was carried out on primary school children only. The participants were selected from different primary schools of West Bengal state, India. About 905 participants were included in this study. Among them, 445 were boys and 460 were girls. The age range of the participants was 5-10 years. A stratified two-stage random cluster sampling was utilized for selecting participants. At first, fifteen clusters (village) were selected from each district. Then systematic random sampling method was used to identify 15 participants per cluster. All the households in the cluster were listed and were divided by the required number of participants to get the sampling interval. The first households were selected randomly by using the lottery method and then subsequent households were identified by adding the sampling interval to the random number. Prior to the experimental trial, the protocol was explained verbally in local language (Bengali) and informed consent was obtained from the participants. They were measured on the same day or another as per their agreement by fixing prior appointments. Ethical approval and prior permission were obtained from the institutional Ethics Committee before commencement of the study and the experiments was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. The numbers of participants selected for the study for different subgroups are mentioned in respective chapters and tables.

4.1.1 Inclusion criteria **:** The eligibility criteria for recruitment of the participants for the study were - age between 5 to 10 years, apparently healthy, not suffering from any acute illness, not having any physical deformity .

4.1.2 Exclusion criteria: The children who were suffering from neuro-psychological disorder and other acute illness, using different antipsychotic drugs for a period of time, orthopedically challenged were excluded from the study. Boys and girls having age below 5 years and above 10 years were not taken for this study.

4.2. Study of Socioeconomic Status:

The socioeconomic status of study participants was evaluated by modified Kuppuswami scale (Chhabra and Sodhi, 2012). The educational level of the subjects was evaluated by questionnaire technique. The subjects were grouped to illiterate, primary educated, upper primary educated, secondary educated, etc. From the response of the parents of subjects total monthly income of the family was noted. The socioeconomic status of the children was determined by the scores suggested in this scale. The score obtains by each person in education, occupation and income was added to get the final score and accordingly the subjects were categorized. Three different categories from the lower to upper have been suggested in this scale.

Socioeconomic gradient	Score
Lower socioeconomic status	1-10
Middle Socioeconomic status	11-25
Upper Socioeconomic Status	26-29

4.2.1 Study of sociodemographic status

A pre-structured schedule questioner containing different sociodemographic variables (Parental years of education, Parental income, parental occupation, family size) was used to determine sociodemographic status of the study participants. The score of parental years of education was determined by interviewing the parents of their educational level (Noble et al.2015) .

According to their educational level the score was given as such.

Educational Level	Years	Score
Post graduate	17	17
Graduate	15	15
Post high school diploma	12	12
High school certificate	10	10
Middle school certificate	8	8
Primary school certificate	4	4
Illiterate	0	0

The score of parental occupation was determined by asking the parents of their occupation by questionnaire methods. The occupational score of the parents was determined by modified Kuppuswami scale as presented below:

Occupation	Score
Profession	10
Semi Profession	6
Clarical,Shop- Owner,Farmer	5
Skilled worker	4
Semi skilled worker	3
Unskilled worker	2
Unemployed	1

Parental income was scored by asking the parents of their monthly income. On the basis of monthly income of parents, the income score was determined according to Kuppuswami scale of socioeconomic status which is shown below:

Monthly income in INR	Score
≥ 32050	12
16020-32049	10
12020-16019	6
8010-12019	4
4810-8009	3
1601-4809	2
≤ 1600	1

The score of family size was determined by interviewing the parents about the number of members in their families. The score was as follows:

No of member in family	Score
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10

4.3. Nutritional Status:

Nutritional status of the children had been assessed by the two methods:

4.3.1. Nutritional Assessment:

Nutritional status of the children was evaluated by questionnaire method. For this purpose 24 hours recall method was employed (Swaminathan 1999). The quantity of different food items taken by the subjects in last 24 hours was recorded in the standard format. The process was repeated for three consecutive days and average of the each food item taken was computed. From the average quantity of the food consumed by the subjects, the amounts of energy, carbohydrate, protein, fat, minerals and vitamins were calculated by using ICMR (ICMR 2009) food composition table.

4.3.2. Anthropometric Index:

Anthropometric measurements are the useful tools for the nutritional assessment, particularly in the field condition where it is difficult to conduct clinical and laboratory test (Johnston 1981). Weight and stature are the two basic measurements used for assessing nutritional status (WHO 1986).

1. Weight: The body weight of the participant was measured by a portable weighing machine with an accuracy of 0.1 kg.
2. Height: The vertical distance from floor to the vertex was taken as the body height of the subjects. Subjects were asked to stand erect. The head was oriented in the eye-ear plane; measured by an anthropometric rod.

Body Mass Index (BMI):

From measures of height and weight of the participants, the body mass index (BMI) was computed.

BMI: The body mass index (BMI) was computed by the following formula (Park 2005):

$$\text{BMI} = \text{Weight (kg)} / \text{Height (mt)}^2$$

Thinness defined as BMI below the 5^{th} percentile for age and overweight-obese defined as BMI above the 85^{th} percentile for age using the NHANES I reference population (WHO 1983. 1995).

Stunting was defined as low height-for-age. Stunting was determined by Z score system. The Z-score system expresses the anthropometric value as a number of standard deviations or Z-scores below or above the reference mean or median value. A fixed Z-score interval implies a fixed height for children of a given age.

The formula for calculating the Z-score was

Z-score (or SD-score) = (observed value - median value of the reference population) / standard deviation value of reference population.

The WHO Global Database on Child Growth and Malnutrition used a Z-score cut-off point of <-2 SD to classify low height-for-age as moderate stunting. Z score cut off point of <-3 SD was used to define severe stunting (WHO 1983. 1995).

4.4. Determination of cognitive skill:

4.4.1.Colour trails test (D'Elia 1986):

This is a measure of focused attention and conceptual tracking. The participants were asked to serially connect the numbers 1–25 printed in two colours irrespective of the colour on colour trails. They were required to connect the numbers serially from 1 to 25 alternating between pink and yellow circles and disregarding the numbers in circles of the alternate colour on colour trails. Time taken to complete each part was the score.

4.4.2 Colour cancellation test (Kapur 1974):

This is a measure of visual scanning /selective attention. It consists of 150 circles in red, blue, yellow, black and grey. The participants were required to cancel only the yellow and red circles as fast as they can. Time taken in seconds to complete the test comprised the score.

4.4.3. Picture completion test (Malin 1969):

It is a measure of visuoconceptual ability, visual organization and visuo-conceptual reasoning. It consists of 20 cards with pictures of different objects with a missing feature. The participants are required to name or point out to the missing feature. Number of correct responses comprised the score

4.4.4 .Ray's auditory verbal learning test (Leandro et al. 2007):

The Ray's auditory verbal learning test (RAVLT) is a neuropsychological test of verbal learning and episodic declarative memory. The RAVLT was used to produce scores that measured short-term auditory-verbal memory, rate of learning, learning strategies, retroactive, and proactive interference, presence of confabulation of confusion in memory processes, retention of information, and differences between learning and retrieval.

In this experiment a list of 15 words (list A) was read loudly to the subject for consecutive 5 times. Each of the attempts was consisted of test of spontaneous retrieval. After the completion of fifth attempt, a list of interference, also consisted of 15 words (list B), was read to the subject and after reading of the words the students were asked for its retrieval (attempt B1). After attempt B1, the examiner instructed the individual student to recall the words which was belonged to list A, without reading the list again the individual student was instructed to recall it again (attempt A6). For the evaluation of learning curve of the words during attempts A1 to A5, the learning rate during the attempts – learning of trials (LOT) was calculated by the following formula:

Sum of A1 to A5 - (5 × A1).

After an interval of 20-minutes, the examiner again asked the individual to remember the words that were belonged to list A, without reading the list (attempt A7). After the attempt A7, the individual was asked to attend for the test of memory recognition, in which a list that consisted of 15 words from list A, 15 words from list B along with 20 distracting words (similar to the words in list A and B in phonological or semantic terms) were read to the individual. Then each of the word read aloud, the individual was asked to indicate if the word belongs to list A, or not. The total time for application of the RAVLT ranged from 35 to 40 minutes. The total sum of attempts, from 01 to 05, and the rates of proactive interference were calculated by (B1/A1); retroactive interference was calculated by (A6/A5) and forgetting speed was calculated by (A7/A6). The result of the memory recognition test was calculated by adding the correct answers (when the individual correctly identified that the word belonged /did not belong to list A) - 35(total of distracting words). This same procedure, used in recognition memory tests, allowed to evaluate not only identification of targets (words in list A), but also took into account the effect of false positives (identification of distracting words) and false negatives (unidentified words in list A).

4.4.5. FAS phonemic fluency test **(***Thais et al.2009***)**

The participants were instructed to generate as many words as possible beginning with letters “F’’, “A” and “S” within a 1-minute period for each letter, excluding proper nouns such as people’s, city and country names and the same word with a different suffix. The following instructions were given: “If it is said wills a letter of the alphabet. Then, the subjects have to give answers as many words the subject say that begin with this letter, as quickly as possible. For example, if it is said B, the subject has to say bed, big, but they can't say proper nouns like Brazil or Beatriz. Also subject can't say the same word with a different ending". Subsequently, the subjects were asked if they had understood these instructions. Words with one, or more than one meaning were also considered, if the subject pointed out the alternative meaning. Words in other languages that were included in the Bengali Dictionary and widespread words even if not in the dictionary also counted. When the participant corrected their response, this was not considered an error. The final score only included correct answers. The following items were considered errors: intrusions (i.e.: when appropriate answers for a letter were given, but inappropriate in terms of letter used at that time; perseverations (i.e. same words were repeated twice or more); derivations (i.e., words that were varied in number, size, gender and verb conjugations).

4.5 Methodology of motor ability test :

4.5.1. Reaction time test (ruler catching method) *(Koshinski et al.2005)*

In one way we can test reaction time in lab is by measuring the time it takes to catch a ruler dropped by an accomplice.

4.5.2 Determination of Reaction Time (RT)

Method 1 -Simple Reaction Time

Subject should hold out the chosen hand and extend the thumb and index finger so they were 8 cm apart. Accomplice held a metric ruler with its end exactly even with the subject's extended thumb and index finger. The ruler should be vertical with lowest numbers near the subject's hand.

i) The ruler was dropped, and the subject was asked to grasps it between the thumb and index finger.

ii) Examiner had to record the number at the subject's fingertips, i.e. distance the ruler fell through the subject's fingers.

iii) Calculation was done the time it took for the subject to react and catch the falling ruler. The time (t) it took for the ruler to fall can be calculated from the distance it fell. Distance (d) fallen can be converted to time (t) passed with the following formula:

$d \text{ (in cm)} = (1/2)(980 \text{ cm/sec}^2)t^2$

$t^2 = d/(490 \text{ cm/sec}^2)$

$t = \sqrt{[d/(490 \text{ cm/sec}^2)]}$

[980 cm/sec^2 is the acceleration of a falling mass on Earth. Since we know how fast an object falls, we can figure out how long it took to fall a measured distance.]

4.5.3. The Purdue Peg Board Test (Desai et al. 2005)

The Purdue pegboard is intended to measure two types of activities (1) gross movements of the hands, fingers and arms; and (2) finger dexterity, which can be considered the ability to integrate speed and precision with finely controlled discrete movements of fingers. This apparatus is a wooden pegboard with four cups for pins, collars and washers at the top of the board, and two columns of 25 holes each at the centre of the board. The four tests conducted using this equipment included a test with the right hand, a test with the left hand, a test with both hands, and an assembly test.

In preparation for the Purdue pegboard test, participants were seated comfortably at a normal table height. The pegboard was placed directly in front of the participants, with cups containing pins, collars and washers at the far end of the pegboard. It was ensured that cups at the extreme right and extreme left of the centre contained 25 pins each, and the cups immediately to the right and left of the centre contained 50 collars and 100 washers each, respectively. Participants were then instructed that the goal of the experiment was to determine how many pegs, or assemblies for an assembly task, they could complete in 30 seconds. They were then instructed carefully, one step at a time, the tasks by the researchers, and were allowed time to practice each task until they felt comfortable. The participants were also reminded that in the actual test they should not worry about pins or other assembly components that drop, and should proceed with the experiment using components that were available on the pegboard. For tests, depending upon which dominant hand of participant, instructions were provided for both of the right-handed test and the left-handed test. The dominant hand considered as the hand which is used most and the use of hand which is less compared to other is the non dominant hand. For the right hand test, participants were instructed to pick one pin at a time with their right hand from the right-hand cup. They were then asked to place each pin in holes along the right-hand column of the pegboard, beginning from the top hole. Participants were instructed that they had to place as many pins as they could, working as rapidly as possible, until the investigator requested them to stop at the end of 30 seconds. The number of pins placed in 30 seconds with the right hand, which was monitored with a stop watch, was recorded. For the left-hand test, participants were instructed to pick one pin at a time with their left hand from the left-hand cup. Participants were requested to place the pins in holes along the left-hand column of the pegboard beginning from the top hole, working as rapidly as possible. The number of pins placed in 30 seconds with the left hand was recorded. For the test requiring both hands, participants were instructed that they were to use both hands at the same time for the tasks. They were instructed to pick up a pin from the right-hand cup with their right hand, and at the same time pick up a pin from the left-hand cup with their left hand. They were to then place the pins down the right-hand and the left-hand column of the pegboard, respectively, beginning from the top of the board. The total number of pins placed with both hands in a 30s time interval was recorded.

For the Purdue pegboard assembly task, participants were required to pick up one pin from the right-hand cup with their right hand, and while they were placing it in the top hole along the right-hand column of the board, to pick up a washer with their left hand. As soon as a pin was placed, they were directed to drop the washer over the pin. While the washer was being placed, participants were to pick up a collar with their right hand. While the collar was being dropped over the pin, they were to pick up another washer with their left hand and drop it over the collar. This series of tasks completed the first assembly consisting of a pin, a washer, a collar and a washer. Participants were instructed that when the final washer for the first assembly was being placed with their left hand, they were to begin the second assembly immediately by picking up another pin with their right hand, and continue placing it in the next hole. The total number of pieces assembled in 30s was recorded. Since each assembly consisted of four pieces, each piece placed in the pegboard was counted as a point, and each completed assembly was counted four points.

4.6 Determination of norms of parameters for grading cognitive skills and motor ability of the children

For grading the cognitive skills and motor ability of the children curve grading norms was employed. The grading of the parameters was done for different ages of girls and boys separately.

Curve Grading is based on the mean and standard deviation of a group of scores. The curve grade indicated the grade on a curve, that actually demonstrated mean and standard deviation that are needed for presenting the score.

4.6.1. Methods for computation for curve grade norms :(Johnson and Nelson ,1986)

Step 1: Mean and standard deviation of the scores was computed for each of the variavle.

Step 2: Five common letter grading system (A, B, C, D and F) was assigned the grades a standard deviation range, as follows:

A=More than 1.5s above the mean

B= Between +0.5s and + 1.5s above the mean

Step 3: Range of C was determined (C range extend above and below the mean, its determination facilities calculation of the other grade range).

C= between -0.5s and +0.5s from the mean.

Step 3: Range of D was determined. The upper limit of D was exactly the upper limit of C and lower limit of D was 1.5 s below the mean

D= Between -0.5s and -1.5 s below the mean.

Step 4: Range of F was determined by

F= More than 1.5s below the mean.

Step 9: Frequency and percentage of the score was established from the grade range. Theoretical percentage was computed. These percentages are taken from tabled value of the percentages of scores in the normal probability curve that fall ±0.5 standard deviation and ±1.5 standard deviation from the mean.

4.7. Statistical Analysis :

Descriptive statistics of different variables of the participants were presented as means ± standard deviation and those were calculated for all the variables. To test the significant difference of the variables, the t - test was performed. Pearson’s correlation coefficient (r) was computed to test the association between two or more the variables. One-way analysis of Variance (ANOVA) was employed to find the significance of difference among different groups. Post-hoc analysis (Bonferroni) was carried out to test for differences in performances across the different groups. To address the potential for confounding, regression analyses was undertaken. Age , Height, Weight, BMI, and Socioeconomic status were entered into the model as independent variables against the performances of the parameters of cognitive skills and motor ability that were considered as dependent variables. P-value set at <0.05 level. Statistical analyses were performed using the statistical software IBM SPSS version 20.

4.8. Hypothesis of the study

In the present investigation some statistical hypothesis were generated. The following null hypothesises were taken into consideration for the study.

1. (A). The score of the cognitive skills and motor abilities will remain unchanged across the ages of the children.

(i) Ho: μ Cognitive skills(age5) = μ Cognitive skills(age6) = μ Cognitive skills(age7) = μ Cognitive skills(age8) = μ Cognitive skills(age9) = μ Cognitive skills(age10) .

Ha: μ Cognitive skills(age5) ≠ μ Cognitive skills(age6) ≠ μ Cognitive skills(age7) ≠ μ Cognitive skills(age8) ≠ μ Cognitive skills(age9) ≠ μ Cognitive skills(age10) .

(ii) Ho:μ Motor abilities (age 5) = μ Motor abilities (age 5)= μ Motor abilities (age 5)= μ Motor abilities (age 5)= μ Motor abilities (age 5)= μ Motor abilities (age 5).

Ha : μ Motor abilities (age 5) ≠ μ Motor abilities (age 5) ≠ μ Motor abilities (age 5) ≠ μ Motor abilities (age 5) ≠ μ Motor abilities (age 5) ≠ μ Motor abilities (age 5)

1. (B) It was hypothesized that there should be no gender difference in the cognitive skills and motor abilities.

(i) Ho: μ Cognitive skills (Male) = μ Cognitive skills (Female)

Ha: μ Cognitive skills (Male) ≠ μ Cognitive skills (Female)

(ii) Ho: μ Motor abilities (Male) = μ Motor abilities (Female)

Ha: μ Motor abilities (Male) ≠μ Motor abilities (Female)

2 (C) The cognitive skills and motor abilities will not differ with nutrient intake of the students.

(i) Ho: μ Cognitive skills (under nourished) = μ Cognitive skills (adequately nourished) .

Ha: μ Cognitive skills (under nourished) ≠ μ Cognitive skills (adequately nourished) .

(ii) Ho: μ Motor abilities (under nourished) = μ Motor abilities (adequately nourished)

Ha: μ Motor abilities (under nourished) ≠ μ Motor abilities (adequately nourished)

3 A) It was hypothesized that there will no change in Cognitive skills and motor abilities due to changes of BMI of the children.

(i) Ho: μ Cognitive skills (Under weight) = μ Cognitive skills (Normal weight) =μCognitive skills (Over weight or Obese).

(ii) Ho: μ Motor abilities (Under weight) = μ Motor abilities (Normal weight) = μ Motor abilities (Over weight or Obese).

Ha: μ Cognitive skills (Under weight) ≠ μ Cognitive skills (Normal weight) ≠ μCognitive skills (Over weight or Obese).

Ha: μ Motor abilities (Under weight)≠ μ Motor abilities (Normal weight) ≠ μ Motor abilities (Over weight or Obese)

4. It was further hypothesized that there will no changes of Cognitive skills and motor abilities between stunted and non stunted children.

(i) Ho: μ Cognitive skills (Stunted) = μ Cognitive skills (Non stunted)

Ha: μ Cognitive skills (Stunted) ≠ μ Cognitive skills (Non stunted)

(ii) Ho: μ Motor abilities (Under weight)= μ Motor abilities (Non stunted)

Ha: μ Motor abilities (Under weight) ≠ μ Motor abilities (Non stunted)

5. It was hypothesised that there would be no changes in cognitive skills and motor abilities in variation to Socioeconomic status of the children.

(i) Ho: μ Cognitive skills (LES) = μ Cognitive skills (MES)= μ Cognitive skills(UES).

Ha: μ Cognitive skills (LES) ≠ μ Cognitive skills (MES) ≠ μ Cognitive skills (UES).

(ii) Ho: μ Motor abilities (LES) = μ Motor abilities (MES)= μ Motor abilities (UES).

Ha: μ Motor abilities (LES) ≠ μ Motor abilities (MES) ≠ μ Motor abilities (UES).

6. It was also hypothesized that there will be no significant association of cognitive skills and motor abilities with age, nutritional, anthropometric and socioeconomic parameters.

Results & Discussions

Chapter V

Contents

Variation of cognitive skills and motor abilities on age and sex

Part 1

Contents

5.1. Variation of cognitive skill of the children on age and sex

5.1.1. Results

The performances of cognitive skills of the primary school going children have been presented in Tables 1 and 1a according to the age of the subjects. From the ANOVA results it was revealed that there were significant variations ($p< 0.001$) of the scores of cognitive abilities among the children of different ages. The mean scores of colour trail test (CTT) of boys and girls of lower age group were significantly greater ($p<0.001$) than that of other higher age groups. The results also indicated that mean scores were significantly decreased ($p<0.001$) with the advancement of age. The same trends of results were noted in case of colour cancellation test (CCT). The mean scores of CCT were also significantly decreased ($p<0.001$) with the advancement of age of boys and girls (Table 1), which indicated betterment of CCT score with the increase of age of the boys and girls.

Table 1: Scores (Mean ±SD) of different cognitive parameters of boys and girls of age groups 5 -10 yrs

			CTT (Sec)		CCT (Sec)		PCT	
Age (yrs)	Boys (n)	Girls (n)	Boy	Girl	Boy	Girl	Boy	Girl
5	67	75	144.02±55.20	141.8±50.12	147.98±62.64	144.01±49.88	3.38±0.98	2.45±1.04
6	76	80	125.64±62.19	112.48±57.86	124.02±61.89	107.12±43.22	3.68±1.15	2.68±1.19
7	79	72	111.34±45.45	106.13±50.77	126.11±61.87	112.54±44.20	3.78±1.00	2.87±1.05
8	83	80	95.67±37.30	97.77±43.35	109.61±44.46	99.83±38.17	3.90±1.15	2.95±1.11
9	74	70	101.24±54.77	89.58±41.50	103.27±52.20	86.84±45.82	4.13±0.96	3.10±1.35
10	66	83	88.90±42.52	77.63±40.77	93.34±47.58	84.96±43.42	4.25±1.33	3.31±1.27
F ratio			11.66***	16.48***	8.33***	18.10***	5.46***	5.15***

***p<0.001. [CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test]

It was found from the Bonferroni post hoc analysis of picture completion test (PCT), which represented visuospatial function of the boys and girls, that the children of the lowest age group (5 years) had the lowest mean values in compare to other higher age groups (7-10 years). The mean PCT scores were increased significantly with the increase of age (Table 1)

The mean scores of phonemic fluency test (FAS) of boys and girls was significantly lower ($p<0.001$) in youngest age group than that of other higher age groups. The mean scores were found to be enhanced significantly with the increment of age of the children (Table 1a).

Similarly, the mean scores recognition (REC) and learning of trials (LOT) , which represented verbal learning and verbal memory of the children were increased significantly ($p< 0.001$) with age with highest score in oldest boys and girls.

Table 1a: Scores (Mean ±SD) of different cognitive parameters of boys and girls of the age

AGE (yrs)	GENDER		FAS		REC		LOT	
	Boys (n)	Girls (n)	Boy	Girl	Boy	Girl	Boy	Girl
5	67	75	2.34±1.43	3.36±1.98	5±1.41	5.84±1.98	6.37±2.63	6.90±2.57
6	76	80	2.6±1.66	3.77±1.72	6.90±2.66	7.27±2.50	7.26±2.88	7.91±3.28
7	79	72	3.06±1.51	4.30±2.11	6.94±1.83	8.62±1.95	8.35±2.80	9.15±3.20
8	83	80	3.15±1.71	4.36±2.04	7.29±2.96	8.78±2.15	9.45±4.45	9.56±3.62
9	74	70	4.09±2.24	5.31±2.05	7.97±3.00	10.44±2.18	9.48±3.75	10.40±3.18
10	66	83	4.68±2.83	5.66±3.11	9.28±4.48	11.26±3.03	10±4.00	11.03±3.51
F ratio			14.65***	12.11***	16.07***	55.56***	11.55***	17.28***

***$p<0.001$ [FAS -Fas phonemic fluency test , REC- recognition LOT-learning of trials]

The correlation coefficients of different cognitive parameters in respect to age were presented in Table 2. Correlation analysis demonstrated that age was significantly ($P<0.001$) and positively correlated with all the scores of cognitive task variables except colour trail test (CTT) and colour cancellation test (CCT). It was noted that age had significant ($P<0.001$) negative correlation with the scores of colour trail test (CTT) and colour cancellation test (CCT). Negative correlation of colour trail test (CTT), colour cancellation test (CCT) with age that indicated that the children took lesser time to complete the test when the age increased. It was meant that the boys and girls showed better cognitive performance in terms of CTT and CCT in higher ages.

Table 2: Correlation coefficient of different cognitive parameters of studied boys and girls with age

Cognitive parameters	Boys	Girls
CTT	-0.323***	-0.376***
CCT	-0.284***	-0.370***
PCT	0.240***	0.230***
FAS	0.336***	0.336***
REC	0.371***	0.608***
LOT	0.330***	0.396***

***p<0.001 [CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test, FAS -Fas phonemic fluency test. REC- recognition, LOT-learning of trials]

Linear regression analysis of age with different cognitive parameters such as colour trail test (CTT), colour cancellation test (CCT), picture completion test (PCT), phonemic fluency test (FAS) and verbal learning and memory test (LOT, REC) was performed and it was revealed that age had significant association with different cognitive parameters (Tables 3 and 4). Multiple regression analysis demonstrated that even after controlling for the effect of height, weight, BMI, socioeconomic status, the age had strong significant impact on all the cognitive parameters. Therefore, the age might be the best account for the variability of the cognitive performances.

Table 3: Regression analysis of cognitive parameters with age (**Boys**)

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-10.41	1.45	-0.323	0.104	51.19	7.17 ***	**-6.46**	**1.89**	**-0.201**	**-3.40 *****
CCT	-10.00	1.60	-0.285	0.081	38.78	6.22 ***	**-5.82**	**2.20**	**-0.166**	**-2.64 ****
PCT	0.165	0.032	0.240	0.058	26.88	10.756 ***	**0.074**	**0.042**	**0.108**	**1.785**
FAS	0.463	0.056	0.367	0.135	68.28	8.236 ***	**0.265**	**0.074**	**0.210**	**3.59 *****
REC	0.669	0.083	0.372	0.138	70.37	8.38 ***	**0.323**	**0.123**	**0.172**	**2.63 ****
LOT	0.745	0.101	0.331	0.110	53.99	7.34 ***	**0.336**	**0.148**	**0.149**	**2.26 ****

***p< 0.001 , # adjusted Height, Weight, BMI, Socioeconomic scores,

[CTT- colour trail test,CCT- colour cancellation test, PCT- picture completion test.FAS -Fas phonemic fluency test. REC- recognition , LOT-learning of trials] .

Table 4: Regression analysis of Cognitive parameters with age (Girls)

Variables	Unadjusted						Adjusted #			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-11.31	1.29	-3.77	0.142	75.80	-8.70***	**-8.92**	**1.90**	**-0.297**	**-4.67*****
CCT	-10.35	1.21	-3.71	0.137	72.96	-8.54***	**-7.01**	**1.80**	**-0.251**	**-3.89*****
PCT	0.161	0.032	0.230	0.053	25.66	5.066***	**0.221**	**0.0057**	**0.315**	**3.86*****
FAS	0.462	0.060	0.337	0.113	58.52	7.65***	**0.325**	**0.106**	**0.237**	**3.02*****
REC	1.048	0.064	0.608	0.370	268.75	16.39***	**0.708**	**0.102**	**0.411**	**6.92*****
LOT	0.813	0.088	0.396	0.157	85.22	9.23***	**0.641**	**0.160**	**0.312**	**3.99*****

***p<0.001 , # adjusted Height, Weight, BMI, Socioeconomic scores

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test.FAS -Fas phonemic fluency test. REC- recognition , LOT-learning of trials]

Gender variation of different parameters of cognitive abilities has been presented in Table 5.The results showed that girls outperformed boys in most of the cognitive performances. The girls showed significantly lower mean scores ($p<0.05$ or less) of CTT, CCT than that of boys. As the girls completed the test in a significantly lesser time, they possessed a better performance in attention tasks (in terms of CTT and CCT) than that of the boys. The mean scores of phonemic fluency test (FAS) and verbal learning and memory tests (LOT and REC) were significantly greater ($p<0.001$) in girls than that of boys . However, the performances of visuospatial function, which was represented by PCT, of the boys were significantly greater ($p<0.001$) than that of girls.

Table 5: Comparison of different cognitive parameters between boys and girls

Cognitive parameter	Boys	Girls
CTT	110.87 ± 53.10	103.93 ±51.71*
CCT	117.42 ±57.85	105.63±48.15**
PCT	3.85*** ±1.13	2.89 ±1.20
FAS	3.30±2.07	4.46*** ±2.36
REC	7.21 ±3.09	8.71***±2.9
LOT	8.50 ±3.70	9.17 **±3.53

* p<0.05, **p<0.01, ***p<0.001with respect to boys
[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test, FAS -Fas phonemic fluency test, REC- recognition, LOT-learning of trials]

5.1.2. Growth of cognitive skill in boys and girls :

The growth curves of different cognitive parameters of boys and girls have been presented in Figs. 1 to 6. It was noted that the scores of the colour trail test (CTT) were gradually decreased with the age (Fig. 1). Time taken for performing the tests (CTT) was gradually reduced with the increase of age. Thus the findings represented that the ability of attention of the boys and girls was increased with the increment of the age. The boys showed higher rate of growth than that of girls, except in the group of 8 years.

Fig. 2 showed that the scores of colour cancellation test (CCT) were gradually reduced with the increment of age of the boys and girls. This revealed that the performances of selective attention of the children were improved with the advancement of age. The boys had higher growth rate of selective attention than that of the girls.

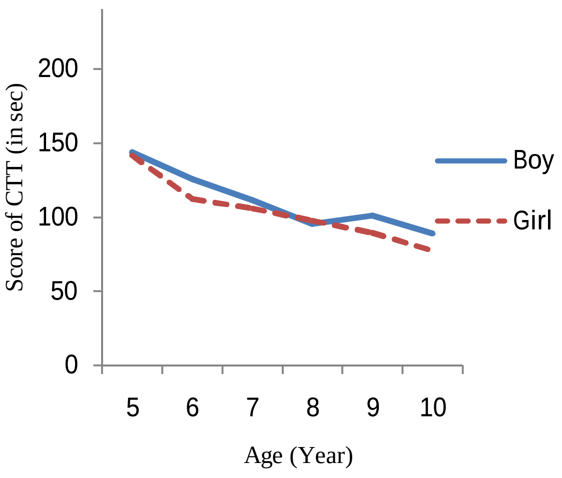


Fig. 1: Variation of the scores of colour trail test (CTT) with age in boys and girls

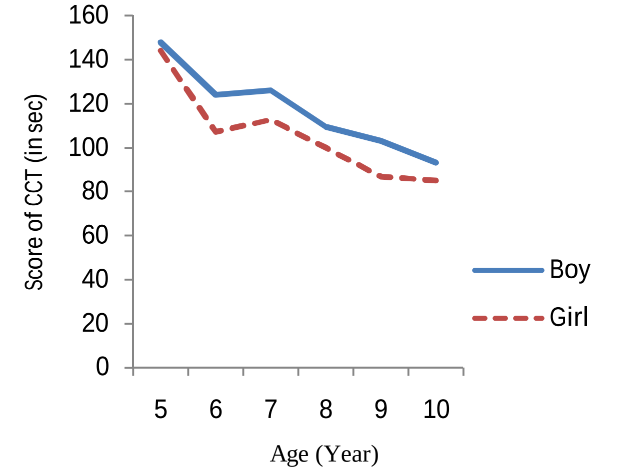


Fig 2: Variation of the scores of colour cancellation test (CCT) with age in boys and girls

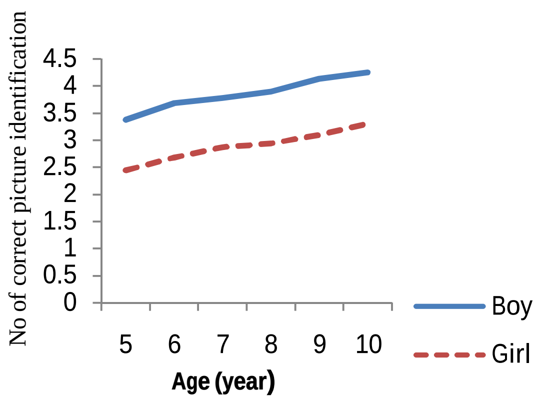


Figure 3: : Variation of the scores of picture cancellation test (PCT) with age of the boys and girls

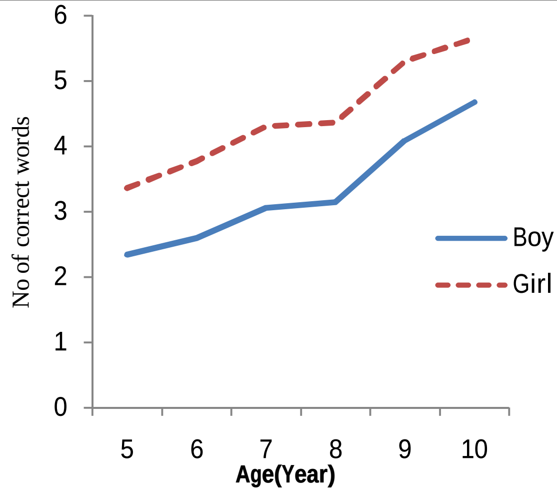


Figure-4: Variation of the scores of FAS with age of the boys and girls

The growth curve of the picture cancellation test (PCT) showed that the scores of the test were gradually increased with the age of the children (Fig. 3) representing better visuospatial function of the boys and girls with the advancement of the age. The boys showed higher rate of growth of this characteristic than that of girls.

The growth of FAS scores of the children, which represented the ability of phonic fluency, were found to be increased with age (Fig. 4). In this case the girls had higher growth of phonic fluency due to age than that of the boys.

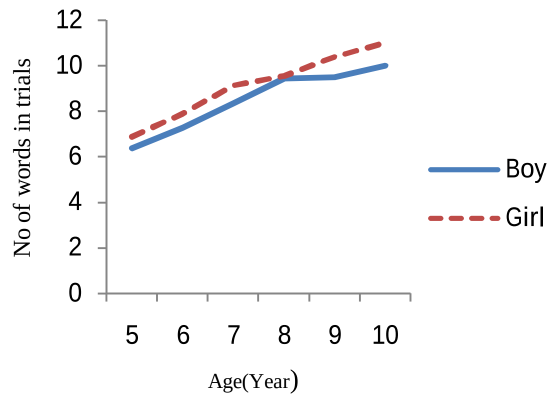


Figure 5: Performances of verbal learning(LOT) variation to age and sex

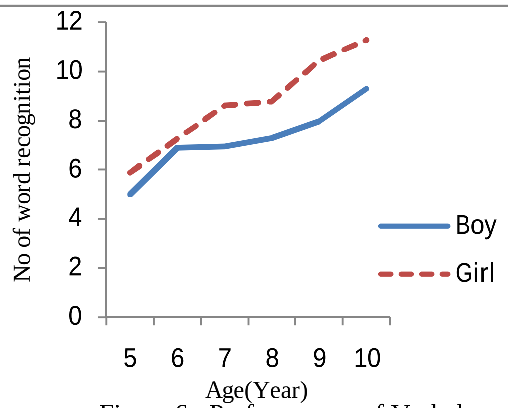


Figure 6: Performances of Verbal recognition (REC) variation to age and sex

From the Figs. 5 and 6 it was observed that the growth curves of the scores of learning of trials (LOT) and recognition (REC) showed upward shift with the increment of the age of the children. The pattern of the growth curve showed age related betterment in the ability of verbal learning and verbal recognition in boys and girls. In both the cases girls had better growth in those cognitive characteristics than that of the boys.

5.1.3 Percentile growth of cognitive skills of primary school children.

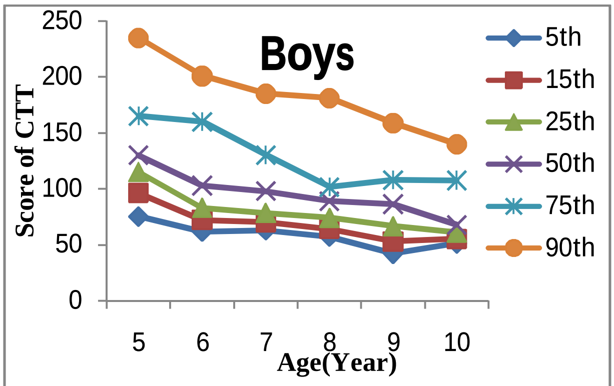


Fig-7: Comparison between different percentile values of CTT for age.

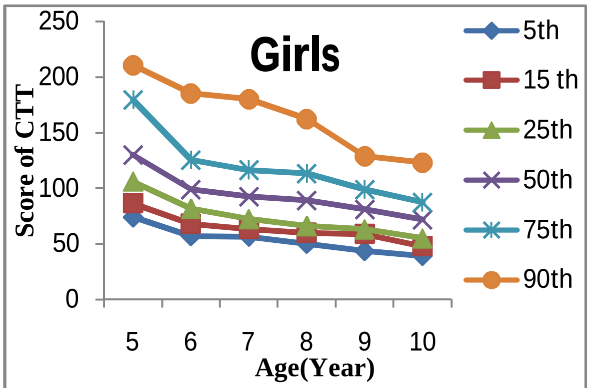


Fig-8: Comparison between different percentile values of CTT for age

In the different studies it was found that lower cut off values for cognitive skills were 10 percentile and upper cut off values were 90 percentile (Brito 1987;Khilari and Narayan 2014). It was also noted from the studies that lower cut off values for motor abilities were 15th percentiles and upper cut off values were 90 percentiles (Cool et al. 2009). In this present study above mentioned protocol , that is, the lower anr15th percentile and 90th percentile values were taken as the lower and upper cut-off values for motor and cognitive parameters.

Different percentile values of Colour trail test and colour cancellation test of both boys and girls were presented in figures 7 to10. From the figures it was noted that performances of colour trail test (CTT) and colour cancellation test (CCT) of both boys and girls at below 15th percentile indicated lower score. Being a time parameter score the growth of colour trail test and colour cancellation might be treated as good performances. The performances level at 50th to below 90th percentile level showed average to low level of performance. Due to same reason the score above 90th percentile indicated very low level of performances.

Figure 11 to14 and 15 to 18 showed different percentile growth curves of different cognitive skills parameters such as Picture completion test (PCT), Phonemic fluency (FAS), Verbal learning (LOT) and verbal memory (REC) respectively. Performances of cognitive skills at below 15th percentile might be considered as very poor development of cognitive skill. Performances of cognitive skills above 90th percentile values were indicated very good development in cognitive skills.

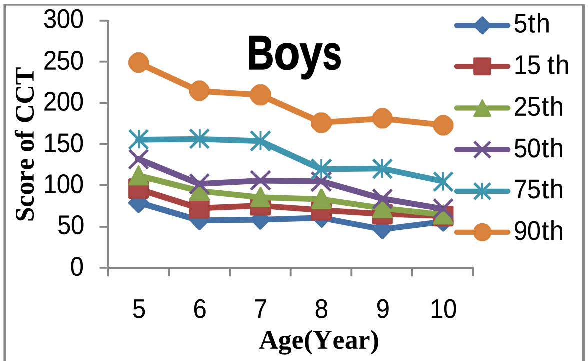


Fig-9: Comparison between different percentile values of CCT for age.

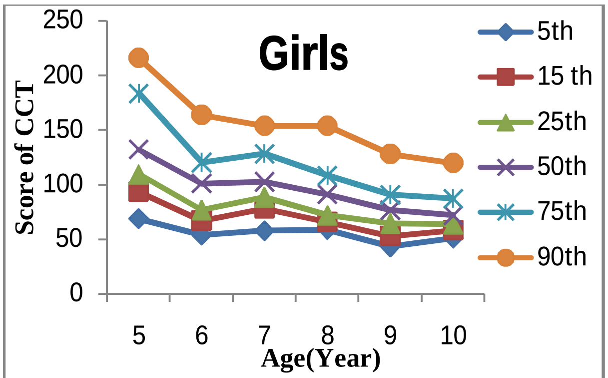


Fig-10: Comparison between different percentile values of CCT for age.

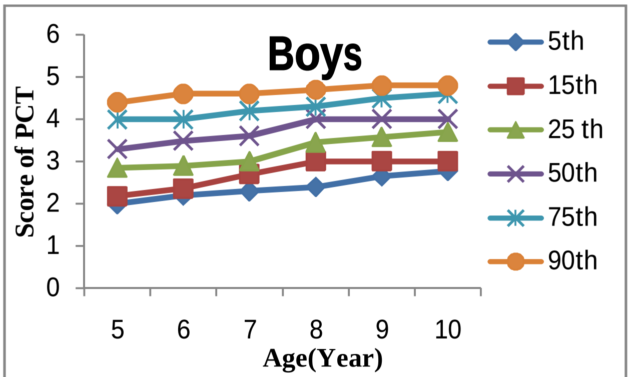


Fig-11: Comparison between different percentile values of PCT for age.

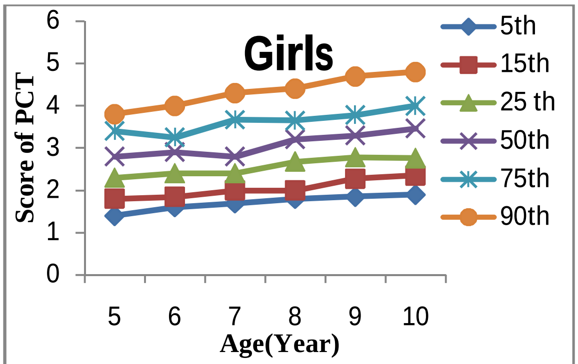


Fig-12: Comparison between different percentile values of PCT for age.

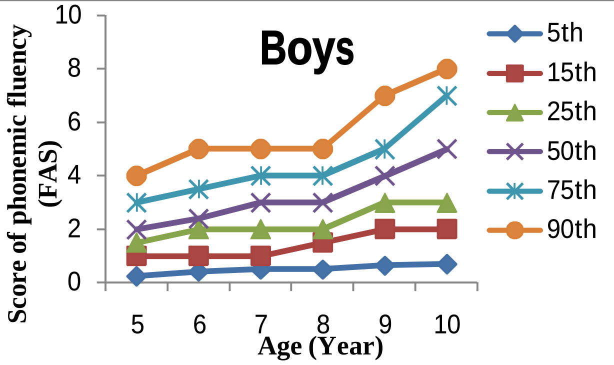


Fig-13: Comparison between different percentile values of FAS for age.

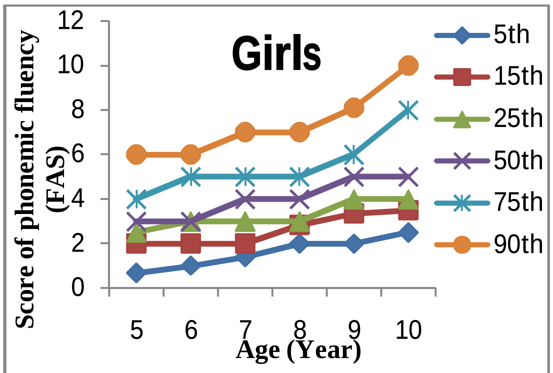


Fig-14: Comparison between different percentile values of FAS for age.

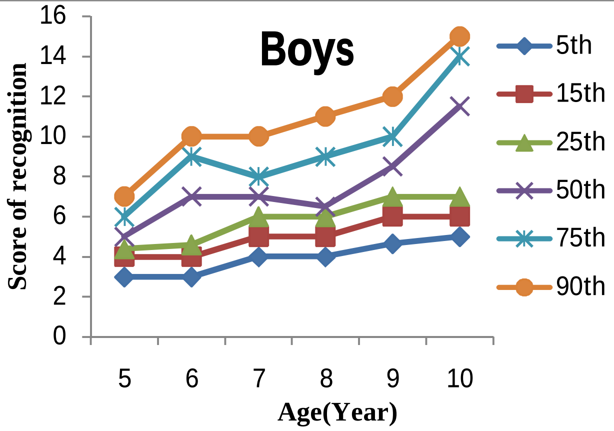


Fig-15: Comparison between different percentile values of REC for age.

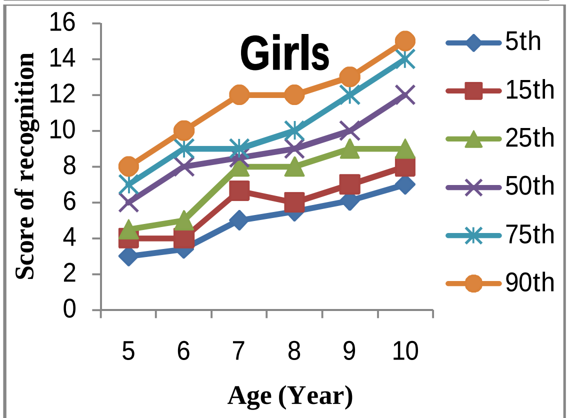


Fig-16: Comparison between different percentile values of REC for age.

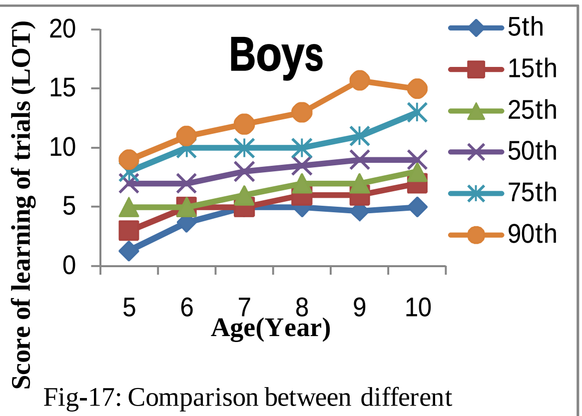


Fig-17: Comparison between different percentile values of LOT for age.

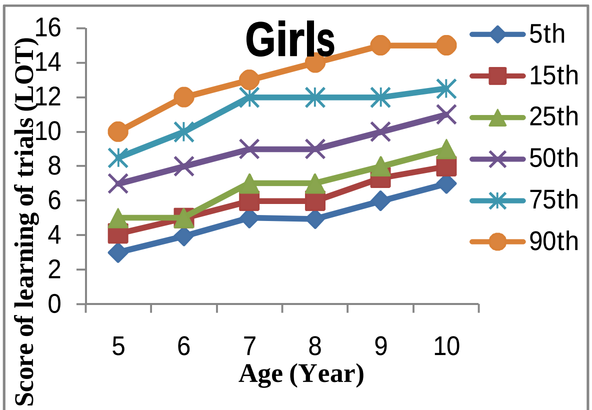


Fig-18: Comparison between different percentile values of LOT for age.

5.1.4. Discussion:

5.1.4.1. Age and gender related variation of visuospatial ability and verbal learning and verbal memory

Visuospatial ability refers to a person's capacity to identify visual and spatial relationships among objects. Visuospatial ability is measured in terms of the ability to imagine objects, to make global shapes by locating small components, or to understand the differences and similarities between objects. Visuospatial skills allow us to visually perceive objects and the spatial relationships among objects. These are the skills that enable us to recognize a square, triangle, cube or pyramid.

Verbal Learning is typically associated with the memorization and retention of lists of words, in order to describe basic elements of associative learning. The types of mental events that occur in verbal learning studies go beyond passive memorization, as learners can play a very active role in manipulating experimental stimuli.

From the results of the present study it was noted that visuospatial ability, verbal learning and memory were increased gradually in both boys and girls from the age of 5 years to 10 years. Such variations might be related to the neurophysiological functioning of the brain. Baddeley (2000) and Manna et al. (2016) reported that the articulatory process, which was mediated through articulatory loop, was the key factor for gradual increase of verbal learning and memory. This can be explained with Baddeley's (1986) tripartite model of working memory. The articulatory loop, responsible for storing speech based information, is comprised of two components. The first component is a phonological memory store which can hold traces of acoustic or speech based material. It was also shown that the articulatory loop had positive effect on age. Baddeley (2000) proposed that the better cognitive performance of young children was due to the activity of the two main components, viz., articulatory loop and episodic buffer. The key function of the episodic buffer was to integrate the information from the articulatory and visuo-spatial loop along long term memory material (Query et al., 1980). It has long been recognized that males and females exhibit differential performance on various cognitive tasks, including tests of visual–spatial and verbal domains (Kimura 1996., Wegesin 1998).

Gender variation of visuospatial ability (picture completion test) was noted among the children of primary school age and it was found that boys outperformed girls (Fig.3). However, in case of verbal learning ability and verbal memory particularly verbal fluency of girls was found to be better than that of the boys (Fig. 5 & Fig. 6). The findings of this study was similar to that of the findings of other studies (Halpern et al., 2007., Moreno et al., 2010) which also suggested that boys had better performance than that of girls in visuospatial ability. Other earlier studies had suggested that males perform better than females on tests of visuospatial functioning (Kimura 1996). Our results were also supported by the aforementioned studies.

From the results (Table 5) it was revealed that performances of verbal learning and verbal memory in girls were better than that of boys. These findings were supported by the results other studies (Saykins et al. 1995 ., Kimura 1996). They also suggested that performances of girls were better than males in tasks of verbal fluency as well as verbal learning and memory. Study of positron emission tomography (PET) and single photon emission computed tomography (SPECT) conducted by different groups of investigators (Li et al. 2004 ., Kastrup et al. 1999., Gur et al. 1995) to find out the functional asymmetry and cerebral metabolic rate and cerebral blood flow between male and female and suggested that females had a higher regional cerebral blood flow than males. The functional imaging studies, including functional magnetic resonance imaging (fMRI) had been conducted by other researchers (Fischer et al. 2004., Lee et al. 2002 & 2005., Weiss et al. 2003., Georgopoulos et al. 2001., Cowan et al. 2000., Ragland et al. 2000., Speck et al. 2000) to investigate gender influence upon regional brain activity changes and the changes of regional cerebral blood flow occurred during stimulus presentation. They showed that significant patterns of differential activation occurred in visuospatial function and verbal learning and memory between the sexes. Gender-specific alterations in brain activation was observed in insular and thalamic regions (Lee et al, 2005), occipital and cingulate regions (Fischer et al. 2004., Lee et al. 2002), frontal regions (Lee et al. 2002), parietal regions (Weiss et al. 2003), and temporal regions (Ragland et al. 2000), as well as altered lateralization between the hemispheres (Lee et al. 2002., Georgopoulos et al. 2001., Speck et al., 2000., Levin et al. 1998., Shaywitz et al. 1995).

Shaywitz et al. (1995) suggested that females have greater bilateral activation during a phonological language task. Speck et al. (2000) pointed out that the greater lateralization occurred in the left hemisphere during a working memory task. Additionally, Weiss et al. (2003) pointed out that females had more frontal activation, compared to more parietal activation in males, during a verbal learning and verbal memory tasks and also showed that males had a greater bias towards right hemisphere activation (and females to left hemisphere activation) during a task requiring a judgement of a whole object from its parts (Georgopoulos et al. 2001).

While some of the cognitive paradigms had demonstrated that gender biases in terms of performance (females perform more accurately, although slower, on working memory task) (Speck et al., 2000) and on memory recall (Ragland et al. 2000), others have not (verbal test of orthographic, semantic, and phonological processing Shaywitz et al. 1995., visuospatial test of mental rotation., Weiss et al. 2003).

Previous studies (Kimura 1996) suggested that males performed better than women in cognitive measures of visuospatial ability. In the present study, however, it was found that performances of girls were better than males in tests of verbal function (Fig.5 & Fig.6). Such difference in findings might be due to difference of age group of the subjects used in the studies. In previous studies adult male and female were the participants. However, Bell et al. (2005) observed a significantly increased activation, over the regions involved in carrying out a verbal fluency task, in males compared to females. The fact was explained by analysis of BOLD signal. The most common functional imaging signal is the Blood Oxygenation Level Dependent signal (BOLD), which primarily corresponds to the concentration of deoxyhemoglobin (Barbe et al. 2012) .The BOLD effect is based on the fact that when neuronal activity is increased in one part of the brain, there is also an increased amount of cerebral blood flow to that area which is the basis of hemodynamic response. This increase in blood flow produces an increase in the ratio of oxygenated haemoglobin relative to deoxygenated haemoglobin in that specific area. A regional analysis revealed that a greater BOLD signal magnitude was observed in males, compared to females in several brain regions (right and left dorsolateral prefrontal cortex, cingulate and right inferior parietal cortex). Structural brain differences and brain composition differences influence the BOLD signal, as well as regional cerebral blood flow, blood volume, and cerebral metabolic rate of oxygen was reported (Vogt et al. 1992). Visual stimulation in males and females contain a greater number of undetectable BOLD signals were present in males than in females were established (Marcar et al. 2004). In a similar investigation, reported that decreased BOLD signal response in females during binocular visual stimulation, compared to males (Levin et al. 1998) that might be reason for lower visuospatial function of girls compared to that of boys.

5.1.4.2. Age and sex variation of executive function of the children

Executive functions are a set of cognitive processes – including attentional control, inhibitory control, working memory, and cognitive flexibility, as well as reasoning, problem solving, and planning – that are necessary for the cognitive control of behaviour. The executive function such as attention is tested by colour trail test (CTT) and colour cancellation test (CCT) and FAS phonemic fluency test. It was noted from the results (Table 1 &1a) that the task of attention (CTT, CCT) and phonemic fluency (FAS) of both boys and girls were gradually increased from the age of 5 years to 10 years. It might be caused due to gradual development of the different brain areas that were responsible for the different cognitive performances.

Brain development is a temporally extended and complex process, with different parts and functions of the brain developing at different times (Grossman et al. 2003). By 5 weeks after conception in humans, the anterior-posterior and dorsal-ventral axes of the neural tube is usually developed (Levitt 2003). The cortical plate (which is the forerunner of the cerebral cortex) and some inter-neuronal connections form from 8 to 16 weeks of gestation (Kostovi´c et al. 2002., Levitt 2003). It was reported that from 24 weeks of gestation until the perinatal period, the neurons in the cortical plate die and are replaced by more mature cortical neurons. During this time, significant refinement in neural connections take place (Levitt 2003). From 34 weeks post-conception until 2 years of age, peak synapse development, and significant brain growth occurs (Levitt 2003). By preschool age, synaptic density has reached the adult level. The myelination of some parts of the brain (particularly those that control higher cognitive functions, such as the frontal lobes) continues well into adolescence, whilst myelination occurs earlier in other parts of the brain that coordinate more primary functions (Toga et al. 2006). Although the gray matter (which contains the bodies of nerve cells) reaches asymptote by the age of 7–11 in different regions of the brain, it was thought that the growth of the white matter (which represents axonal nerve tracts) continues beyond 20 years of age.

Studies had shown that the maturation of specific brain areas during childhood was associated with development of specific cognitive functions such as language, reading, and memory (Nagy et al. 2004., Deutsch et al. 2005., Giedd et al. 2010). The development of the frontal lobes, which are believed to control higher cognitive functions (including planning, sequencing and self-regulation), appears to occur in growth spurts during the first 2 years of life, and then again between 7 and 9 years of age and also around 15 years of age (Bryan et al. 2004).

The development of some sub cortical structures including the basal ganglia, amygdale, and hippocampus (which was also centrally involved in some mediating higher cognitive functions, including memory, executive functions, and emotion) also continues until late adolescence. In addition, a meta-analysis had confirmed a connection between the size of the hippocampus and memory performance during brain development in children and young adults (Van 2004). Overall, the research evidence suggested that cognitive development was strongly connected with micro and macro-anatomical changes which took place throughout childhood (Levitt 2003., Herlenius and Lagercrantz, 2004., Ghosh et al. 2010).

From the results of the present study (Table 5) it was noted that performances of the girls on attention and phonemic fluency task was better than that of their boy's counterpart (Figs. 1&2.Figs.4). The executive task and phonemic fluency task is the function of pre-frontal cortex. The similar type of findings were noted by a number of research groups (Giedd et al .1999., Matsuzawa et al. 2001 .,Ragland et al. 2002., Gogtey et al .2004., Gur et al .2007 .,Perrin et al .2009). Liu et al.(2013) found no sex differences in executive and alerting of attention networks but faster orientation of attention among females. Popovich et al. (1984) also found greater female responsiveness in attention to processing overall sensory stimulation. Neuroimaging study reported that the boys showed significantly greater loss of grey matter volume and increases in both white matter compared with same age range and also showed that a significant development of girls that changes with age but slower rate than boys. The other cross sectional studies performed by Jernigan and Taller, (1990) ; Jernigan et al. (1991); Pfeffeerbaum et al .(1994); Caviness et al. (1996); Giedd et al.(1996); Reiss et al .(1996b) and another longitudinal investigation by Giedd et al .(1999b); Ropoport et al. (1999),Thomson et al.(2000) showed a significant age related decreases in cerebral grey matter and also increases in cerebral white matter volume and cerebral cortical area where as intracranial and cerebral volume and they also showed that intracranial and cerebral volume did not changes significantly.

The longitudinal study by Oberai et al. (1998) demonstrated that age related sex differences in brain maturation and explained that decreased of grey matter that reflected the dendritic pruning process and also explained that grey matter mainly composed of cell and dendrite and that study did not showed any evidence for cell loss during late childhood and adolescence. The researcher also explained that increase of white matter due to either myelination or increase of axonal size and glial proliferation.

However, several cross sectional investigation of human aging (Gur et al.1991.,Kaye et al. 1992; Cowell et al. 1994., Murphy et al .1996) demonstrated that there might be age related atrophy in male compared to female.

5.2. Age and gender related variations in motor development of children

5.2.1 Results:

The performance of motor ability of the primary school going boys and girls has been presented in Table 6 according to the age of the subjects. The results of ANOVA showed a significant variation ($p<0.001$) of motor performances of the participants among different age groups. From the results it was appeared that the performances of the scores of Pegboard test by dominant hand (Fig. 20), non-dominant hand (Fig. 21) and both hand (Fig. 22) were gradually increased from lower age group to higher age group. However, the score of Reaction Time (RT), represented by ruler dropping test, (Fig. 19) showed a gradual decrease in the mean scores significantly ($p<0.001$) with the increase of age. The Bonferroni post hoc analysis showed that the participants belonging to the lower age group performed significantly lower motor ability compared to rest of the age group. The boys and girls of higher age group performed significantly greater scores than that of boys and girls of other age groups.

Table 6: Scores (Mean ±SD) of different motor parameters of boys and girls of the age groups 5 -10 yrs

Age (yrs)	Reaction Time (Sec)		Peg board Score (No of pin inserted)					
			Dominant Hand		Nondominant Hand		Both Hand	
	Boy (n=445)	Girl (n=460)	Boy(n=445)	Girl(n=460)	Boy(n=445)	Girl(n=460)	Boy(n=445)	Girl(n=460)
5	0.299±0.080	0.261±0.077	6.14±2.19	7.41±2.06	6.21±1.57	7.16±2.15	4.96±2.61	5.77±3.05
6	0.264±0.067	0.245±0.058	7.07±2.36	8.37±2.50	6.73±2.20	8.02±2.29	5.35±2.46	7.04±3.21
7	0.259±0.068	0.242±0.060	7.40±2.29	9.08±2.64	7.15±1.91	8.74±2.33	5.75±2.70	7.24±3.07
8	0.229±0.055	0.218±0.054	8.60±2.79	10.06±2.41	8.23±2.51	9.42±2.27	7.75±2.79	8.19±2.58
9	0.221±0.051	0.204±0.055	9.45±2.92	11.43±2.18	8.97±2.28	10.24±1.99	8.51±2.52	9.56±2.73
10	0.200±0.048	0.195±0.054	11.34±1.86	12.40±2.72	10.60±2.26	11.29±2.07	9.44±2.76	10.62±2.68
F ratio	22.04***	13.91***	47.33***	40.79***	45.19***	31.51***	38.19***	26.45***

*p<0.05, **p<0.01, ***p<0.001

Correlation coefficient of motor performance parameters in respect to age were presented in Table 7. Correlation analysis demonstrated that the age was significantly ($P<0.001$) and positively correlated to the scores of Perdue pegboard test performed by dominant hand, non-dominant hand and both hand.

Table 7: Correlation coefficient of motor parameters of studied children with age

Motor parameter	Boy	Girls
RT	-0.440***	-0.360***
Pegboard score -DH	0.572***	0.562***
Pegboard score -NDH	0.562***	0.514***
Pegboard score -Both Hand	0.531***	0.475***

***p<0.001 [RT- Reaction time, DH- Dominant hand, NDH-Non-dominant hand]

On the contrary, the result also showed that the age had significant negative correlation (P<0.001) with the scores of ruler dropping test (reaction time).

Linear regression analysis of age with different motor parameters such as Reaction time (RT) and peg board scores (DH, NDH, Both Hand) was made and results showed that age had significant association with different motor parameters (Tables 8 and 9). Multiple regression analysis demonstrated that even after controlling for the effect of anthropometric parameters (height, weight, BMI) and Socioeconomic status, the age had strong significant impact on all the motor parameters . Therefore, the age might be the best account for the variability of the motor performances.

Table 8: Regression analysis of motor parameters with age (girls)

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
RT	-0.013	0.002	-0.347	0.120	62.59	-7.91 ***	**0.008**	**0.002**	**-0.211**	**-3.78 *****
Pegboard score -DH	0.990	0.066	0.572	0.328	223.15	14.93***	**0.815**	**0.107**	**0.472**	**7.65*****
Pegboard score -NDH	0.0.857	0.059	0.563	0.317	212.26	14.56***	**0.686**	**0.096**	**0.450**	**7.14*****
Pegboard score -Both Hand	0.970	0.072	0.532	0.283	180.34	13.42***	**0.798**	**0.117**	**0.437**	**6.82*****

***p<0.001 # adjusted Height, Weight, BMI, Socioeconomic scores

[RT- Reaction Time, DH- Dominant hand, NDH-Non dominant hand]

Table 9: Regression analysis of motor parameters with age (boys)

Variables	Unadjusted						Adjusted#			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
RT	-0.019	0.002	-0.440	0.194	105.73	-10.28 ***	**-0.015**	**0.002**	**-0.355**	**-7.75 *****
Pegboard score -DH	1.002	0.070	0.562	0.316	202.97	14.24***	**0.835**	**0.094**	**0.469**	**8.86*****
Pegboard score -NDH	0.796	0.063	0.515	0.256	157.90	12.56***	**0.667**	**0.096**	**0.431**	**6.93*****
Pegboard score -Both Hand	0.932	0.082	0.475	0.226	127.98	11.31***	**0.705**	**0.122**	**0.359**	**5.76*****

***p<0.001 # adjusted Height, Weight, BMI, Socioeconomic scores

[RT- Reaction time, DH- Dominant hand, NDH-Non dominant hand]

Gender variation of motor ability parameters has been presented in the Table 10. The result showed that reaction time (ruler dropping test) of girls were significantly lesser (p<0.05) than that of boys. Thus it may be stated that girls had better reaction time in comparison to the boys. Results also showed that performances of hand eye co-ordination (Pardue peg board score) of dominant hand, non-dominant hand and both hands of girls were significantly greater (p<0.001) than that of boys.

Table 10: Comparison of different motor parameter between boys and girls

Motor Parameter	Boys	Girls
RT (Sec)	0.246±0.007	0.227±0.006**
Pegboard score –DH (No of pin inserted)	8.37± 2.97	9.67±2.93 ***
Pegboard score –NDH (No of pin inserted)	8.01±2.62	9.13±2.55***
Pegboard score -Both Hand (No of pin inserted)	6.98±3.14	8.04±3.23***

* p<0.05, **p<0.01, ***p<0.001 with respect to boys; [RT- Reaction Time, DH- Dominant hand, NDH-Non-dominant hand]

5.2.2. Growth of Motor ability in variation to age and sex of the children

The growth pattern of motor abilities of boys and girls according to age has been presented in figs. 7 to 10. It was found from the graph (Fig.7) that performances of reaction time gradually decreased as the age increases. Those findings indicated that performances of reaction time of boys and girls were increased as a function of age. It was also observed from the graphical presentation that the growth of performances of RT test of girls were slightly better than boys.

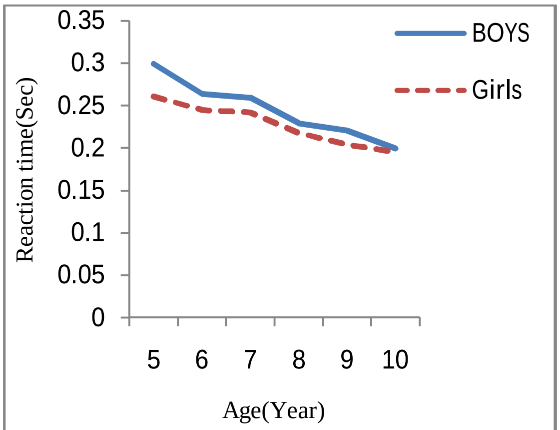


Fig-19: Reaction time of boys and girl as a function of age

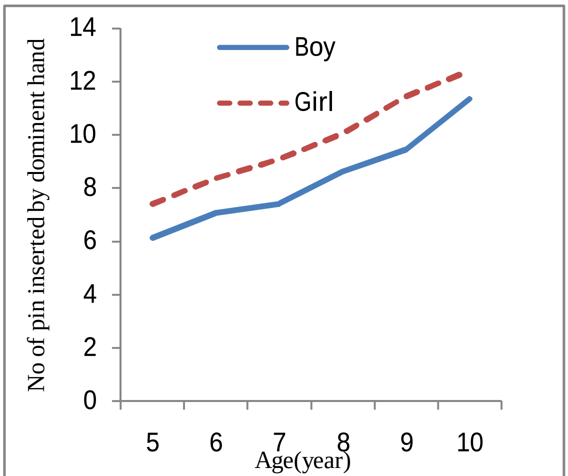


Fig.20: Pegboard score (Dominent hand) of boys and girls as a function of age

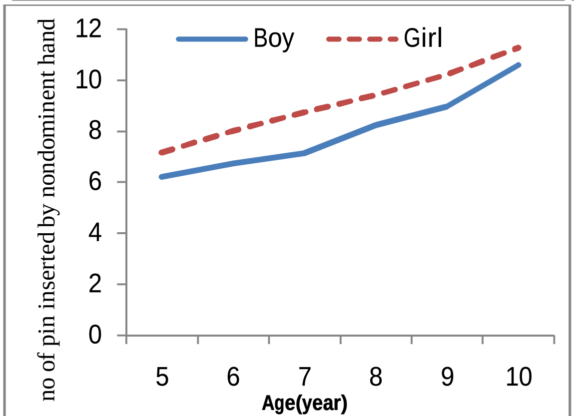


Fig.21: Pegboard score (nondominent hand) of boys and girls as a function of age

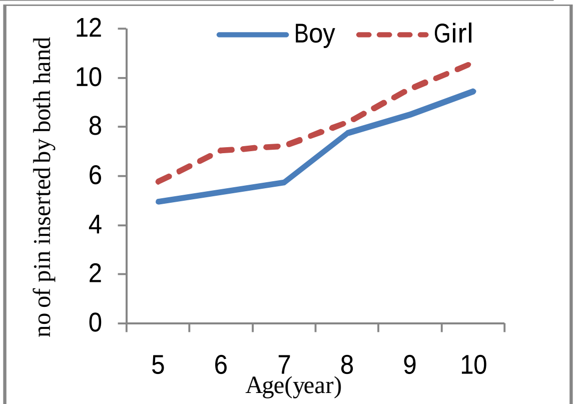


Fig.22: Pegboard score (both hand) of boys and girls as a function of age

The growth pattern finger dexterity represented by the pegboard score, of the dominant hand, non dominant hand, and both hand of boys and girls have been presented in Figs. 20 to 22 respectively. Form the figure it was revealed that there was a positive growth of finger dexterity (pegboard score) in dominant hand, non dominant hand and both hand. Thus it indicated improvement of performances as a function of age. Figures also revealed that the growth curves of girls remained upper side of the curves of the boys indicating better growth in girls.

5.2.3. Percentile growth of motor abilities of the primary school going children.

The percentiles on a growth chart create a curve. As a child grows, plotting the weights and heights on the chart will indicate whether a child is following a curve, which means that the child is remaining near or at the same percentile. Like the physical growth the motor and cognitive growth can be plotted in percentile curves. Following a curve indicates a pattern of healthy growth. Even a 5th percentile can be appropriate for a child if the child follows this percentile curve consistently. The same is true for a child following the 90th percentile. A child at the 5th percentile is just smaller than average, and a child at the 90th percentile is just larger. If a child's growth pattern suddenly changes and weight drops or increases significantly in the percentiles, a careful look may be given for reasons behind the shift.

Figure 23 & 24 showed comparison between different percentile curves of reaction time of boys and girls. From the figure it was noted that the reaction time (RT) below 15th percentile indicated lower scores. As it was a time parameter score the growth of reaction time might be treated as good. Due to the same reason the growth curve of 90th percentile curve of reaction time indicated poor development of reaction time (Cool et al .2009).

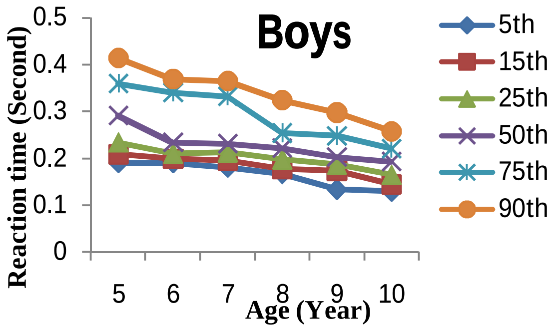


Fig-23: Comparison between different percentile values of reaction time for age.

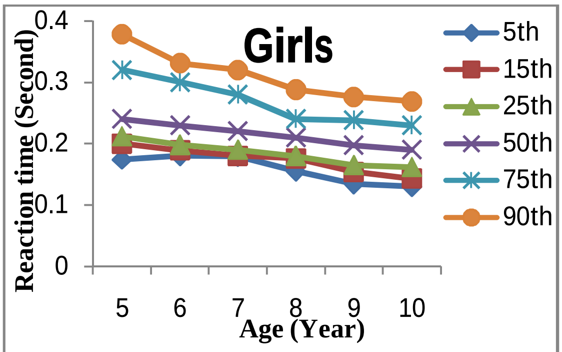


Fig-24: Comparison between different percentile values of reaction time for age.

Figures 25 -28 showed percentile growth curves of hand eye coordination such as pegboard test by dominant hand non dominant hand of boys and girls. Performances of motor ability below 15 percentile were considered as poor development of motor skill. Performances above 90th percentile were considered as very good development in motor ability of the children.

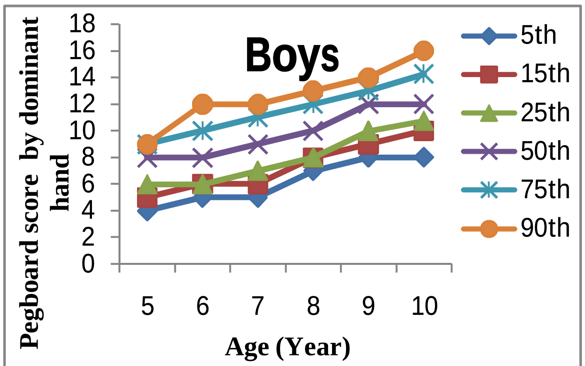


Fig-25: Comparison between different percentile values of pegboard score by dominant hand for age.

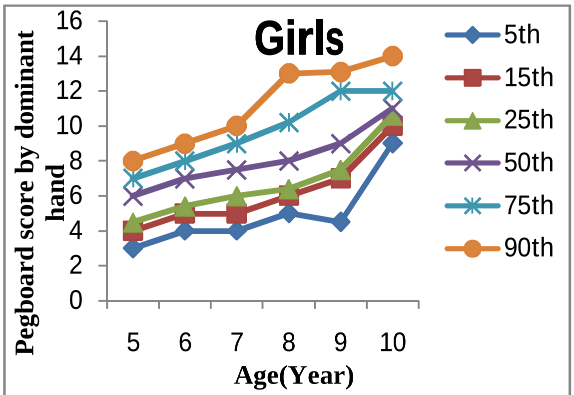


Fig-26: Comparison between different percentile values of pegboard score by dominant hand for age.

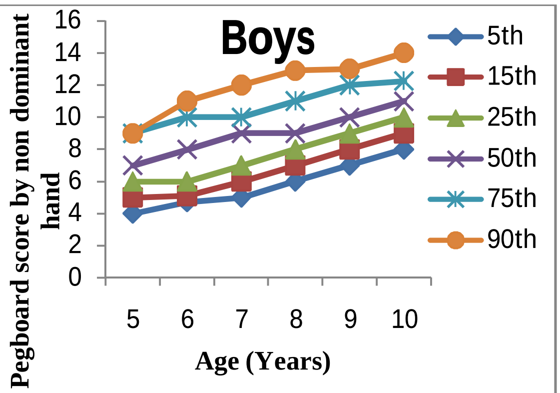


Fig-27: Comparison between different percentile values of pegboard score by nondominant hand for age.

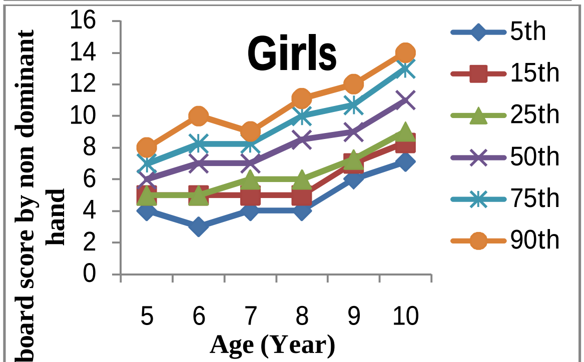


Fig-28: Comparison between different percentile values of pegboard score by nondominant hand for age.

5.2.4. Discussion:

5.2.4.1. Age and gender related variation of motor skills of primary school children.

Motor competence constitutes a significant developmental challenge during preschool years. The present study was designed to investigate the effect of age and gender on motor skills of preschool children. The results showed (Table 6) an improvement in reaction time with the increase of age. The fine motor activity (scores of peg board test) was also enhanced with the advancement of age among boys and girls. Thus the older children presented better scores than that of younger ones. Other investigators reported age-related improvement in visual motor (Gabbard and Hart, 1993) and balance skills (Venetsanou and Kambas, 2011) during preschool years.

The gradual improvement of motor activity from the age 5–10 years (Table 6) suggested an underlying maturational process of the cortex and corticospinal tracts of the nervous system. By using Magnetic Resonance Imaging (MRI) technique Paus et al. (2001) found that the age related improvement of children was due to continuous growth of corpus callosum from childhood to adult hood when he compared with growth of corpus callosum from childhood to adulthood. Earlier, Paus et al. (1999) demonstrated that the corticospinal and thalamocortical tracts that support motor functions also showed age-related maturation.

As far as gender difference in motor ability was concerned, the results (Table 10) of the present study showed that the reaction time was significantly better in the girls compared to that of boys (Figs.20)

The results also revealed that (Table 10) the dexterity and hand–eye coordination, which were represented by the peg board scores, of the girls were better than that of the boys (Figs.21-22).It was noted that the pegboard scores of dominant hand, non-dominant hand, and both hand of the girls showed the same trends of results. The findings of our study was similar to that of some previous studies (Largo et al. 2001., Junaid and Fellows B, (2006) in which it was also reported that performances of pegboard activity of girls were better than boys. Denckla (1973, 1974) noted gender differences in motor development and reported that girls were faster and better coordinated than boys early in the elementary school years, but these differences might disappear by adolescence. Largo et al. (2001) demonstrated that girls tend to display fewer and less pronounced overflow movements throughout childhood. Giedd et al. (1999), by anatomical MRI studies, showed that systems underlying motor development (i.e., frontal and parietal gray matter) reach maximum size one year earlier in girls than in boys. Furthermore, De Bellis et al. (2001) stated that both girls and boys show increase in white matter and corpus callosum volume from 6 years to17 years of age; however, girls show these developmental changes gradually over this age range, while boys show a dramatic increase over a shorter time period, with greater volumetric changes than the girls between ages 10–14 years.

The neural pathways were the important factors for motor systems that underlie patterned movement may mature differently in girls than in boys Chen et al. (1997) and it was concluded that the left hemisphere was more involved in the timing of complex sequences than the right hemisphere. Similar findings were reported by Grafton et al. (2002) and concluded that in time related task involvement of the left hemisphere was greater than right hemisphere. Other studies reported that development of left hemisphere in girls was faster than boys (Grafton et al. 2002., Haaland et al. 2004., Harrington and Haaland, 1991). This might be the reason for gender differentiation motor performances of children. It might also be reason for the different rates of brain maturation and the age-increased myelination of the central nervous system which promotes development of children’s fine motor skills. This interpretation was also supported by the coordinated emergence of neurological functions (Anderson et al. 2001., Klinberg et al. 1999), motor and cognitive advances (Case, 1992) during human development.

Gender differences in motor development have also been attributed to biological factors and more precisely to the differentiated neurological maturation of girls and boys (Piek et al.

2012). Within this context, girls' predominance on both visual motor and hand–eye coordination (pegboard test) could partially be explained by more rapid development of young girls' left hemisphere (Hanlon et al.1999).

These different gender-specific rhythms in brain maturation, could suggest that a 5 to 6-year-old boy need a longer period of time to build up fine motor (small muscle and nerve) skills, which are required for detailed hand work while executing peg board task and reaction time and visual motor tasks.

Nutritional pattern vs. cognitive skill and motor abilities

Part 2

Contents

5.3. Variation of Nutritional status on cognitive and motor performances

Both under nutrition and over nutrition are found among the children in India. Globally, human beings are tending to become heavier and more adipose, as a result of increased food security, wide availability of low-cost energy-dense foods, and increasingly sedentary lifestyles. While this has reduced the prevalence of under-nutrition, childhood and adult overweight/obesity has increased considerably over the last 20 years in high income as well as low- and middle-income countries (WHO obesity 2000., Popkin 2005). It is well established that greater adiposity in childhood is associated with an increased risk of chronic cardio-metabolic disease in later life including hypertension, diabetes mellitus and cardiovascular disease (Daniel 2009). Recent study suggested that adiposity might have other adverse effects on health.

Childhood stunting was one of the most significant impediments to human development, globally affecting approximately 162 million children under the age of 5 years. Stunting, or being too short for one’s age, was defined as a height that was more than two standard deviations below the Child Growth Standards median of World Health Organization (WHO growth standard). It was a largely irreversible outcome of inadequate nutrition and repeated bouts of infection during the first 1000 days of a child’s life. Stunting had long term effects on individuals and societies, including: diminization of cognitive and physical development reduced productive capacity and poor health, and an increased risk of degenerative diseases such as diabetes (state of world's children 2013). Stunting is a well-established risk marker of poor child development. Stunting before the age of 2 years predicts poorer cognitive and educational outcomes in later childhood and adolescence (Walker et al. 2007., Black et al. 2013) and had significant educational and economic consequences at the individual, household and community levels. Recent longitudinal studies on children from Brazil, Guatemala, India, the Philippines and South Africa associated stunting with a reduction in schooling, where adults who were stunted at age 2 completed nearly one year less school than non-stunted individuals (Martorell et al. 2010., Adair et al. 2013).

5.3.1 Nutritional status and cognitive and motor performances

Intake of nutrient by boys and girls in respect to age has been presented in Table 11 and Table12. The result showed that amount of nutrient intake by boys and girls was gradually increased with the advancement of age. The results indicated that nutrient intake of 5 years boys and girls were lower than that of other age groups.

Table 11: Mean±SD of nutrient intake of boys according to age

Age (years)	Protein (g/day)	Carbohydrate (g/day)	Energy (K cal/day)	Folic Acid (µg/day)	Cholin (mg/day)	Omega3 fatty Acid (mg/day)
5	24.98± 5.65	138.71±31.37	859±196.31	102.63±26.73	117.12±65.56	1137.71±386.36
6	30.95±10.27	142.72±44	999.05±282.74	116.93±30.20	163.45±94.92	1377.12±609.46
7	36.40±10.95	166.75±44.30	1163.74±340.59	130.78±49.18	203.51±106.17	1790.65±942.09
8	48.64±16.26	224.40±65.34	1414.76±408.10	161.84±52.42	250.40±133.70	2336.87±1145.94
9	49±14.16	242.26±73.04	1472.51±301.20	188.56±63.95	266.78±145.40	2792.37±1114.09
10	57.80±19.11	274.88±81.97	1771.78±351.24	232.93±67.7	322.70±151.55	3187.46±1194.94
F Ratio	60.11***	64.46***	74.14***	64.80***	26.16***	49.82***

***p<0.001

Table 12: Mean±SD of nutrient intake of girls according to age

Age (years)	Protein (g/day)	Carbohydrate (g/day)	Energy (K cal/day)	Folic Acid (µg/day)	Cholin (mg/day)	Omega3 fatty Acid (mg/day)
5	28.01±7.67	151.72±38.09	894.77±200.53	133.68±60.58	120.07±37.10	1410.12±724.54
6	32.69±7.23	148.70±34.00	828.04±164.71	120.56±62.77	165.74±73.78	1613.63±797.89
7	35.55±9.67	182.01±38.05	1190.25±340.55	167.64±104.37	177.79±100.53	1822.95±983.45
8	49.99±16.45	226.67±66.54	1339.24±343.35	191.55±110.41	246.39±114.01	2051.52±946.02
9	51.44±15.27	232.67±67.27	1493.64±275.45	198.66±86.00	283.60±130.41	2663.88±896.94
10	53.60±14.27	241.46±71.47	1583.77±330.79	210.00±81.26	289.75±134.56	2778.79±1051.64
F Ratio	59.32***	8.09***	89.14***	13.56***	1.24	29.45***

***p<0.001

On the contrary it was also found that nutrient intake of 10 years boys and girls were greater compared to boys and girls of younger age groups. The result of ANOVA showed a significant variation ($p<0.001$) in nutrient intake among the different age groups.

5.3.2. Nutrient intake vs. cognitive and motor abilities

Correlation coefficients of different cognitive and motor parameters with nutrient consumption of the boys and girls have been presented in Tables 13(A) & (B) respectively. It was noted from results that all the cognitive variables of boys and girls were positively and significantly ($p<0.001$) correlated with their nutrient consumption except CTT and CCT. It was found that CTT and CCT of both boys and girls had significant negative correlation ($p<0.001$) with their nutrient intake.

Table 13 (A): Correlation coefficient of cognitive variables with different nutrient intake **(Boys)**

NUTRIENTS	CTT	CCT	PCT	FAS	REC	LOT
Protein	-0.553***	-0.499***	0.461***	0.609***	0.656***	0.529***
Carbohydrate	-0.575***	-0.532***	0.480***	0.648***	0.672***	0.483***
Calorie	-0.574***	-0.517***	0.464***	0.594***	0.656***	0.463***
Folic acid	-0.552***	-0.514***	0.485***	0.627***	0.732***	0.540***
Cholin	-0.566***	-0.523***	0.458***	0.562***	0.628***	0.561***
Omega 3 fatty acid	-0.584***	-0.537***	0.477***	0.636***	0.700***	0.584***

***p<0.001 .

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test. FAS -Fas phonemic fluency test, REC- recognition, LOT-learning of trials]

Table 13(B): Correlation coefficient of cognitive variables with different nutrient intake **(girls)**

NUTRIENTS	CTT	CCT	PCT	FAS	REC	LOT
Protein	-0.428***	-0.421***	0.398***	0.448***	0.524***	0.350***
Carbohydrate	-0.281***	-0.240***	0.250***	0.252***	0.343***	0.296***
Calorie	-0.382***	-0.317***	0.309***	0.352***	0.493***	0.363***
Folic acid	-0.263***	-0.200***	0.167***	0.156***	0.265***	0.216***
Cholin	-0.306***	-0.269***	0.243***	0.245***	0.357***	0.319***
Omega 3 fatty acid	-0.322***	-0.290***	0.242***	0.294***	0.384***	0.303***

***p<0.001

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test. FAS -Fas phonemic fluency test, REC- recognition, LOT-learning of trials]

Correlation coefficient of different motors parameters of boys and girls with their nutrient intake have been shown in Tables 13C and 13D respectively. From the results it was noted that the peg board score of boys and girls had significant positive correlation ($p<0.001$) with their nutrient intake. Thus results indicated that the finger dexterity and gross movement of the upper limb might be dependent on the intake of macro- and micronutrients.

Table 13(C): correlation coefficient of motor variables with different nutrient intake **(Boys)**

Nutrients	Reaction time	Peg board score		
		Dominant hand	Nondominant hand	Both hand
Protein	-0.671***	0.718***	0.683***	0.610***
Carbohydrate	-0.717***	0.732***	0.702***	0.629***
Calorie	-0.702***	0.726***	0.697***	0.628***
Folic acid	-0.685***	0.755***	0.714***	0.650***
Cholin	-0.705***	0.753***	0.734***	0.643***
Omega 3 fatty acid	-0.712***	0.773***	0.721***	0.645***

***p<0.001

The reaction time of boys and girls were significantly and negatively correlated ($p<0.001$) with their nutritional status. Thus the results pointed out that the reaction time of the subjects was lessened with the greater intake of macro- and micronutrients.

It may be mentioned that the degree of correlation coefficients was comparatively greater in case of boys than that of girls.

Table 13(D): correlation coefficient of motor parameters with different nutrient intake (**girls)**

Nutrients	Reaction time	Peg board score		
		Dominant hand	Nondominant hand	Both hand
Protein	-0.442***	0.572***	0.555***	0.474***
Carbohydrate	-0.297***	0.434***	0.434***	0.352***
Calorie	-0.414***	0.494***	0.523***	0.458***
Folic acid	-0.256***	0.323***	0.305***	0.247***
Choline	-0.302***	0.419***	0.445***	0.345***
Omega 3 fatty acid	-0.349***	0.447***	0.449***	0.341***

***p<0.001.

5.3.4.Discussion

5.3.4.1. Effect of dietary protein on cognitive and motor abilities of the children

It was noted from the results that the amount of protein consumption was an influencing factor for motor skill abilities, viz., the reaction time, and finger dexterity as well as upper limb movements of both boys and girls. Opposite effects might be caused due to deficiency of protein, as reported by many investigators. It was observed that protein deprivation can cause direct deleterious effects on the brain, such as reduced brain weight, altered hippocampal formation, impairment of neurotransmitter systems, and changes in protein phosphorylation (Bonatto et al. 2006). The effect of different protein intakes during the first 12 months of life on cognitive development and behaviour in boys and girls at 8.5 years was studied by Koletzko et al. (2009) and they found that protein deprivation could change the anatomical architecture of the brain. It had been reported that protein deficiency reduced the thickness of the visual cortex, parietal neocortex, dentate gyrus, CA3 and cerebellum that affect the cognitive functions (Diaz cintra et al.1990., Ranade et al. 2012). Moreover, Plagemann et al. (2000) determined that the ventromedian nucleus of hypothalamus increased its size while the PVN is reduced after malnutrition, demonstrating that perturbations during development may change the brain organization (Plagemann et al. 2000). Additionally, protein malnutrition changes the number of neurons as well as dendritic arborisation complexity and the number of synapses (Diaz et al.1990). Reduced number of neurons in CA1 region of hippocampus has been described after prenatal protein restriction (Lister et al. 2005). Gender-specific changes were observed on cerebellar development in rats, showing a higher reduction on its size in females compared to males (Hilmann et al. 1981), affecting the granular, the molecular and the myelinated layer was reported. The consequence of malnutrition on brain anatomy, through changes on brain connectivity, might be the cause of behavioural deficits observed in malnourished people. It was shown by investigators that cell reduction of proliferation after pre and postnatal protein deprivation in cerebellum of P7 mice (Ranade et al. 2012) and sub granular zone of young rats (Godoy et al. 2013).

Several groups workers showed that protein malnutrition reduces the quantity and quality of myelin, which changes its composition in offspring brains of the malnourished mums after birth that affected the conduction velocity through nerve fibres, that was cause of poor motor performances (Egwim et al.1986, Montanha et al. 2004). Earlier, a reduction on MBP expression evoked by malnutrition has been found (Dalmau et al. 1998).

5.3.4.2. Effect of dietary Choline on cognitive function and motor skill of children

Choline is known to be an essential micronutrient needed for many functions of the body, especially for brain function. It is a water soluble nutrient that is related to other vitamins, such as folate and those in the B vitamin complex family. It is important for liver function, normal brain development, nerve function, muscle movement, supporting energy levels and maintaining a healthy metabolism**.** The results of present study had shown that the consumption of choline was increased with the increment of age and there was significant correlation between choline and different cognitive functions, viz., visuospatial function and verbal learning and memory as well as motor skills, like, reaction time and finger dexterity in primary school children. Such improvement in those functions might be mediated through the alteration in the function of the brain.

Studies on choline deficiency and supplementation supported the above views. Several investigations on animal model were found in the literature. Evidence from numerous animal studies indicated that dietary choline had an important impact on the cognitive development of offspring (Meck and Williams, 2003; McCann et al. 2006). It had been shown that choline in animal models altered the development of the hippocampus, which had a central role in memory and learning (Zeisel 2006a). It was established that folate and choline also had a role in the closure of the foetal neural tube. It had been known that choline deficiency impaired brain development. In rodent models, multiple studies had reported that choline deficiency and supplementation affect neurodevelopment. It was also established that the offspring of choline-supplemented pregnant rodents have improved visuospatial and auditory memory and perform better in behavioural tests, whereas choline deficiency seems to have the opposite effect (Zeisel 2006). It was postulated that requirement of choline was for the formation of all membranes, including grey and white matter phospholipids, with higher demands during growth (Caudill 2010, Corbin et al. 2012; Zeisel 2013). The developing central nervous system was particularly sensitive to choline availability was reported evidence suggested that low choline availability leads to poor brain development and long-term cognitive and behavioural impairments in rodents (Caudill 2010., Corbin et al. 2012).

It was explained that deficient consumption of choline in diet of pregnant woman, increased incidence of neural tube defects and orofacial cleft defects in infants (Caudill, 2010., Corbin et al. 2012). Studies on adults had reported better cognitive function in those eating diets higher in choline (Poly et al. 2011), but adequately powered studies to determine whether choline nutrition during pregnancy enhances brain development, especially memory (Zeisel 2013). A study among Californian mothers found an increased risk of neural tube defects of their children with lower maternal dietary choline intake, as identified from a food frequency questionnaire (Shaw et al. 2004). There was one study that had evaluated the impact of maternal blood choline (represented across a wide range of concentrations) on intelligence in 5 year old children (Signore et al. 2008).

5.3.4.3. Effect of dietary Folic acid on cognitive function and motor skill development of the children:

In the present study a good correlation has been noted between folic acid consumption and cognitive functions as well as motor skill parameters. The association between maternal blood folate status and cognitive development has been investigated in several studies (Tamura et al. 2005., Veena et al. 2010). They concluded that folate status of mother during pregnancy affect cognitive development of their children at the age of 5–6 years on different cognitive tests including Differential Ability Scales, Visual and Auditory Sequential Memory, Knox Cube, the Gross Motor Scale and the Grooved Pegboard. Veena et al. (2010) reported that higher maternal blood folate concentration was associated with better cognitive performance on a wide range of tests (Atlantis, Word Order, Pattern Reasoning, Verbal Fluency, Koh's Block Design and WISC-III) in 9–10-year-old Indian children. The role of folate in early pregnancy in the prevention of neural tube defects is well established, and it is also fundamental for brain development due to its participation in nucleotide synthesis, methylation processes, DNA integrity, and transcription (Raynolds 2006). It was reported that folates seem to have an effect on memory (Durga et al. 2007). Systematic reviews and meta analysis had shown that supplementation during pregnancy with a multivitamin containing folic acid did not result in a benefit to mental performance in children (Skorka et al. 2012). However, researchers had shown that low maternal folate status during early pregnancy was associated with increased risk of internalising (mood instability, obsessions, somatic problems, nervousness, insecurity, fears, phobias, sadness, apathy, dysphoria, rest lessness, tension, worry, and guilt) and externalising (disruptive behaviours, irritability, impulsiveness, aggressiveness, and inattention) problems in young children (Roja et al. 2010., Steenweg de Graff et al. 2012). Cohort studies also established that folate-supplemented mothers had children with fewer behavioural problems at 18 months of age (Roja et al. 2010), improved scores on verbal, verbal-executive functions, social competence, and attention measures at 4 years (Julvez et al. 2009) and reduced hyperactivity and peer problems at 8 years (Schlotz et al.2010).

5.3.4.4. Effect of dietary omega 3 fatty acid on cognitive function and motor skill development of the children

Omega-3s are “essential” fatty acids because the body isn’t capable of producing them on its own. There are actually three different types of “omega-3s”: ALA (alpha-linolenic acid), DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid). In the present study significant correlation was noted between Omega 3 fatty acid consumption and different cognitive and motor parameters of the children. The matter may be explained by the involvement of Omega 3 fatty acid consumption in the neuronal functioning related to motor and cognitive abilities. The fact may be evidenced by either supplementation of Omega 3 fatty acid or by the deficiency of Omega 3 fatty acid.

Rapid neuronal maturation, synaptogenesis, and gray matter expansion that occurred in infancy, childhood, and adolescence were times of all of which were associated with brain DHA accumulation (Carver et al. 2001., Giedd et al. 1999). DHA was found at high levels in only a very limited number of foods and the typical intake by children worldwide was surprisingly low.

Studies in animals show that omega-3 deficiency causes structural and functional changes in the hippocampus, hypothalamus, and cortex areas of the brain was reported (Lim et al., 2005). In animals, it was shown that reduced levels of brain DHA were associated with problems of spatial and serial learning and memory (Moriguchi and Salem, 2003.,Fedorova et al. 2009) as well as increases in depressive symptoms and aggressive behaviour (De Mar et al. 2006., Fedorova et al. 2006). In humans, DHA is particularly important during gestation and infancy for early brain and visual development (Jensen et al. 2005.,Birch et al. 2007). There is also growing understanding of the role that *n*-3 LC-PUFA may play in the prevention and treatment of several neuropsychiatric conditions common to children and adults (Bloch and Hannested, 2012). Recently, polyunsaturated fatty acids, including DHA, had been studied in children with certain developmental disorders characterized by learning and behaviour difficulties. Many of these conditions were associated with abnormal fatty acid status, and whether due to altered fatty acid metabolism or poor intake, some studies show an improvement in symptoms following supplementation with poly unsaturated fatty acids (Bloch and Qawasmi, 2011., Milte et al. 2011). Healthy children without these neuropsychiatric conditions may also have poor DHA status, due to poor intake. It is therefore plausible that improvements in DHA status could benefit learning and behaviour in healthy children as well.

However, only few observational studies have investigated potential relationships of n-3 fatty acid status and intakes with cognitive performance, academic achievement, and behaviour in apparently healthy children (older than 2 years of age) and early adolescents. The study by Bakker et al. (2009) found a significant positive relationship between umbilical plasma DHA levels and motor function at 7 years of age, whereas plasma DHA at 7 years of age did not correlate with motor function. Higher prenatal DHA intakes (measured as cord DHA) were significantly associated with faster judgment of familiarity of visual information, as well as indicating an enhanced brain activity during the recollection of visual information in memory at 10-13 years of age (Boucher et al. 2011). The author showed in neurophysiological research that significant associations of cord DHA concentrations with improved cognitive performance during childhood. However, it was indicated that reduced levels of inattention, hyperactivity, and emotional and conduct difficulties, as well as for increased prosocial behaviour (reported by teachers and parents) with increasing n-3 fatty status. In the study by Baym et al. (2014), the intake of n-3 fatty acids, measured by a validated food frequency questionnaire, was positively associated with hippocampal-dependent memory accuracy in 7- to 9-year-old children. In contrast, saturated fatty acid intake was negatively associated with both relational and item memory accuracy.

5.3.4.5. Effect of dietary Carbohydrates intake on cognitive function and motor skill development of the children :

From the results the present study it was noted that carbohydrate intake had a strong and positive correlation with cognitive and motor function of the children. Other investigators also noted the effect of carbohydrate supplementation in the improvement cognitive and motor functions of the children. Mohoney et al. (2005) suggested that consumption of carbohydrates on breakfast influenced children’s cognitive performance on some measures, particularly spatial memory, short-term memory, and auditory attention. They also proposed that carbohydrate influenced some aspects of cognitive performance, such as immediate recall, delayed recall and recognition memory. Pollitt et al. (1988) reported that nutrient composition differences of breakfast and meals could affect a range of cognitive tasks that include spatial memory, short-term memory, visual perception, and auditory attention. performances of visual perception task or a spatial memory task was better after consuming either breakfast versus no breakfast at all was reported (Wesnes et al., 2003). Korol et al. (1998) suggested that modest increases in circulating glucose enhance learning and memory. Wartman (1982) reported that influence of carbohydrate was to synthesis of brain neuro transmitter. Waterman also explained that carbohydrate increased brain neurotransmitter such as tryptophan.

5.3.4.6. Effect of dietary calorie consumption on cognitive function and motor skill development of the children

The association of energy consumption with cognitive and motor functions was observed in the present study. Altering the caloric content of the diet was a potential means by which to affect cognitive capacity. Vaynman et al. (2006) pointed out that the brain consumes an immense amount of energy relative to the rest of the body. Thus, the mechanisms that were involved in the transfer of energy from foods to neurons were likely to be fundamental to the control of brain function. Processes that were associated with the management of energy in neurons could affect synaptic plasticity. Vaynman et al. (2006) explained that BDNF (Brain-derived neurotrophic factor, also known as BDNF, is a protein that, in humans, is encoded by the *BDNF* gene) was an excellent example of a signalling molecule that was intimately related to both energy metabolism and synaptic plasticity; it could engage metabolic signals to affect cognitive function. BDNF was most abundant in brain areas that were associated with cognitive and metabolic regulation: the hippocampus and the hypothalamus, respectively was identified (Nawa et al.1995). Hall et al. (2000)., Ma et al. (1998) suggested that learning of human being was regulated by hippocampus and BDNF played a major role for plasticity of hippocampus and genetic deletion of the BDNF gene impairs memory formation.

Cognitive functions may be associated with neural cell metabolism and synaptic function. Certain mechanisms that regulated cell metabolism were integrated with mechanisms that modulated synaptic function. For example, excess calories could reduce synaptic plasticity (Wu et al. 2004) and increased the vulnerability of cells to damage (Mattson 2005) by causing free-radical formation that surpassed the buffering capacity of the cell. Moderate caloric restriction could thus protect the brain by reducing oxidative damage to cellular proteins, lipids and nucleic acids (Mattson 2007). Studies in rodents indicated that elevated oxidative stress decreased BDNF-mediated synaptic plasticity and cognitive function (Vaynman et al. 2006., Wu et al. 2006). Caloric restriction also elevated levels of BDNF (Lee et al. 2002., Duan, 2003) suggesting that BDNF might mediate the effects of low caloric intake on synaptic plasticity. Reducing caloric intake to approximately 40% of control nominal values in mice from weaning to 35 months of age decreased the deficits in motor and cognitive function that were associated with aging (Ingram et al. 1987). Alternate-day feeding ameliorates age-related deficits in cognitive function in a mouse model of Alzheimer’s disease when the feeding programme is maintained between 3 and 17 months of age (Booth et al. 2002).

5.4. Body Mass Index vs Cognitive skills and Motor ability

Part 3

Contents

5.4.1. Effect of BMI and body weight on cognitive skills of children.

5.4.1.1.Results:

BMI is a measure for indicating nutritional status in adults. BMI is also recommended for use in children and adolescents. In children, BMI is calculated as for adults and then compared with z-scores or percentiles. The primary school children were divided into Thinness, normal and overweight/obese according to the cut-off values of BMI (WHO 2006).

The frequencies and percentages of thinness, normal and overweight/obese boys and girls have been shown in Table 14. From the results it has been depicted that the prevalence of thinness in boys (25.16 %) and girls (26.52%) was notable. The percentage of overweight or obese was not much high in boys (7.64 %) and girls (9.13%). The BMI values represented that most of the boys (67.2 %) and girls (64.34 %) were within the normal weight category.

Table 14: Frequency (f) and percentage (%) of subjects showing nutritional status of primary school going children according to BMI

		Nutritional Status		
		Thinness	Normal	Overweight or obese
Boys (n=445)	f	112	299	34
	%	25.16	67.2	7.64
Girls (n=460)	f	122	296	42
	%	26.52	64.34	9.13

The performances of the tests for cognitive characteristics of three body weight groups, viz., Thinness, normal weight, and overweight/obese boys and girls have been compared in Table 15. The ANOVA was computed among the different nutritional groups to find out the level of significance of difference within these three body weight groups. The results showed that the performance scores of different cognitive characteristics, viz., phonemic fluency (FAS), attention (CTT & CCT), visuospatial functions (PCT), verbal comprehension and verbal learning and memory (REC & LOT) in thin and overweight children had significant difference with that of adequately nourished group (p<0.001). The data was further used for post hoc analysis, for comparing the difference in cognitive ability parameters between two groups.

The results of post hoc analysis revealed that scores of task of attention (CTT and CCT) was significantly greater (p<0.001) in children of normal weight compared to the children of thinness and overweight / obese. However, no significant difference was found in the above variables between the children of thinness and overweight /obese.

Table 15: Scores (Mean ±SD) of different cognitive parameters of boys and girls having different nutrition levels

Cognitive parameter	Thinness		Normal		Over weight /obese		F- ratio	
	Boys (n=112)	Girls (n=122)	Boys (n=299)	Girls (n=296)	Boys (n=34)	Girls (n=42)	Boys	Girls
Colour trail test (CTT)	140.01 ±64.34	146.48 ±73.74	104.59 ±52.12 *** ###	89.64 ±36.43 *** ###	135.05 ±42.31	138.80 ±60.42	18.71 $$$	57.26 $$$
Colour cancellation test (CCT)	149.08 ±60.51	144.16 ±58.31	109.99 ±55.48 ***###	90.83 ±33.79 *** ###	134.4 ±43.75	137.50 ±41.84	19.79 $$$	73.27 $$$
Picture complitation test (PCT)	3.15 ±1.08	2.89 ±1.25	3.78 ±1.00 *** #	3.88 ±0.90 *** ###	3.34 ±0.72	3.02 ±0.99	14.05 $$$	43.02 $$$
Fas phonemic fluency test (FAS)	2.71 ±1.95	2.34 ±1.7	3.78 ±2.43 ***	4.13 ±2.02 *** ###	3.02 ±1.40	2.80 ±0.88	9.21 $$$	30.97 $$$
Recognition (REC)	5.91 ±2.04	5.98 ±2.50	8.19 ±3.32 *** ###	8.69 ±3.15 ***###	5.94 ±1.87	6.16 ±2.55	27.62 $$$	38.90 $$$
Learning of trials (LOT)	7.14 ±2.77	7.32 ±3.54	8.74 ±3.74 *** #	8.79 ±3.68 ***#	7.34 ±2.50	7.69 ±2.84	9.51 $$$	7.16 $$$

For F ratio: $$$ p<0.001 w.r.t. thinness * p<0.05, ** p<0.01, *** p<0.001, w.r.t. overweight/obese # p<0.05, ## p<0.01, ### p<0.001

It was noted that the scores of visuospatial function (PCT) of the children belonging to normal weight group was significantly greater (p<0.001) than that of thinness and overweight / obese children. The result of post hoc analysis of the score of phonemic fluency test (FAS) revealed that the performances of the boys and girls of normal weight children were significantly greater than thinness children ($p<0.001$) but no such significant difference was observed in between boys of normal weight and overweight / obese.

The mean scores of verbal learning and verbal memory (LOT) were significantly ($p<0.001$) higher in normal weight children than that of the children of thinness and overweight / obese.

It has been observed from the Table 15 that the scores of colour trail test (CTT) and colour cancellation test (CCT) of boys and girls were lower in normal weight children compared to thinness and overweight/obese children (Figures 29-32). It may be stated that lower score of said variables in normal weight children indicates better performance compared to thinness and overweight or obese children.

Table 15 indicated that the scores of picture completion (PCT) and phonemic fluency test (FAS) of normal weight children were higher than the scores of thinness and overweight / obese children (Figures 33-36). This result revealed that the improvement of the score as BMI varies from thinness to normal or overweight/obese to normal. It was also observed that the scores of Phonemic learning of trials (LOT) showed higher values in normal weight group compared to other two groups. Figures 37-38 indicated that performances of phonemic fluency and the ability of verbal learning in boys and girls had variations with the variation of BMI.

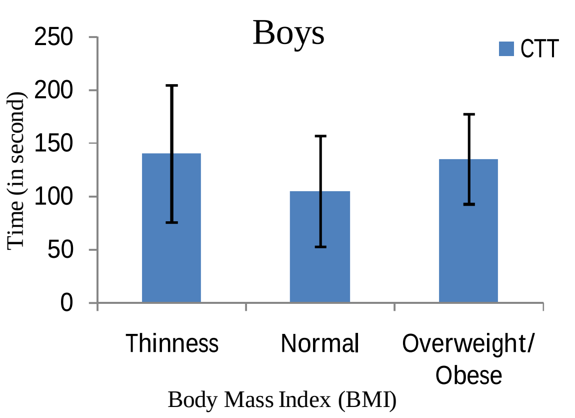


Fig-29: Performances in the test of attention (CTT) in variation to BMI

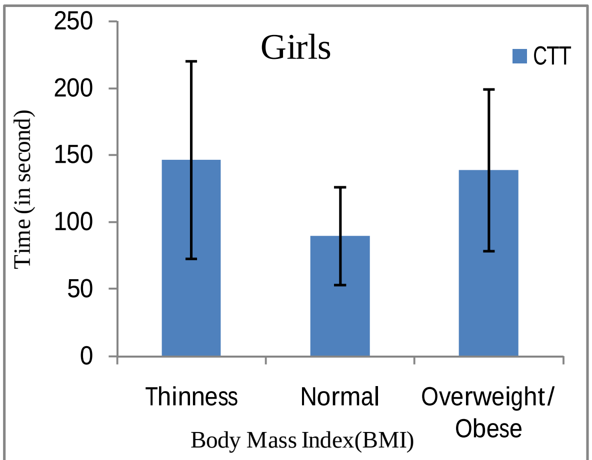


Fig-30: Performances in the test of attention (CTT) in variation to BMI

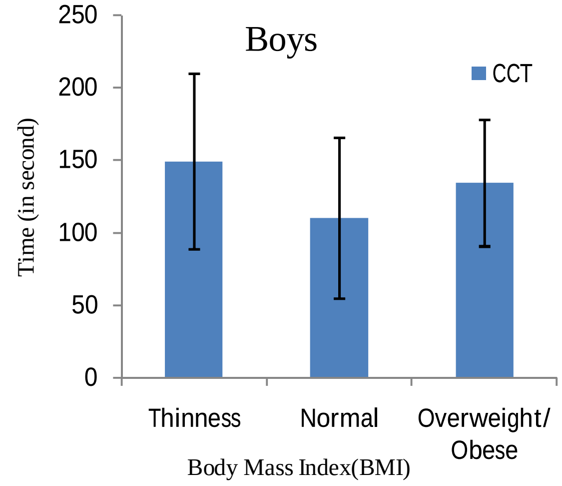


Fig-31: Performances of the score of attention in variation to BMI

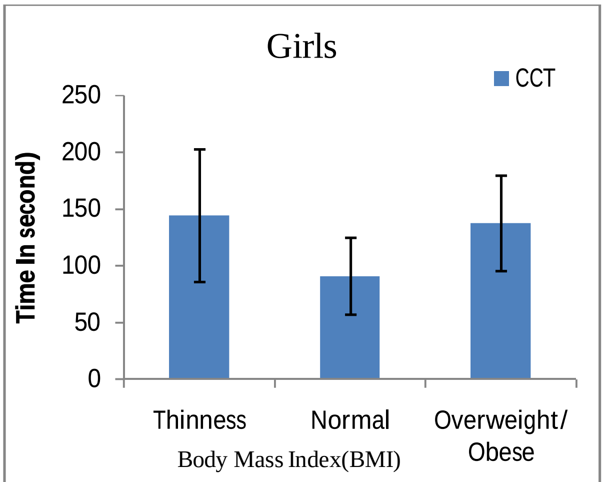


Fig-32: Performances of the score of the test of attention in variation to BMI

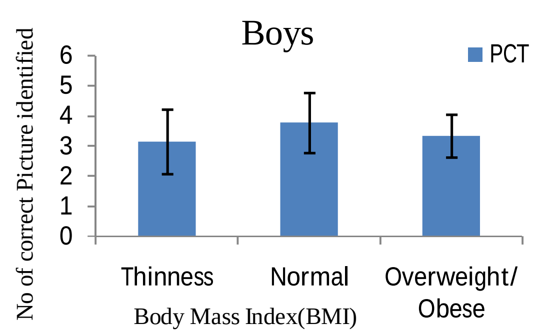


Fig-33: Performances of the score of the visuospatial function(PCT)m in variation to BMI

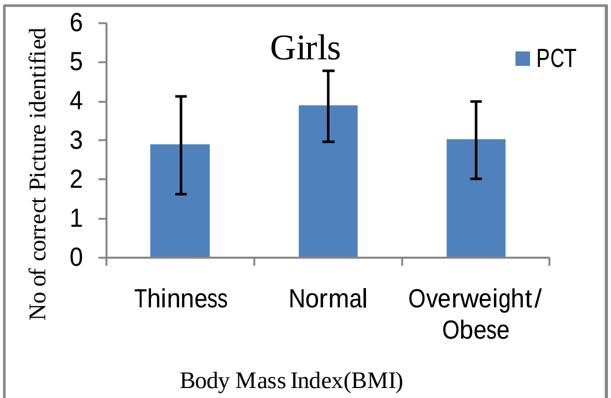


Fig-34: Performances of the score of the visuospatial function(PCT) in variation to BMI

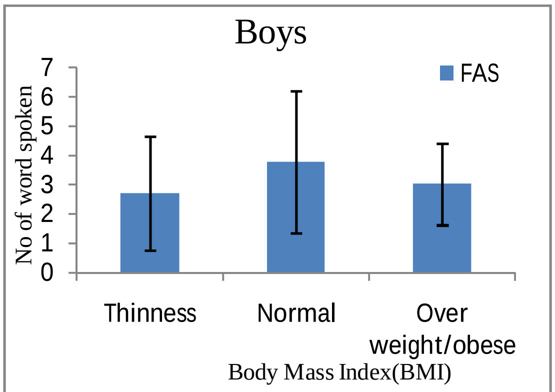


Fig-35: Performances of phonemic fluency in variation to BMI.

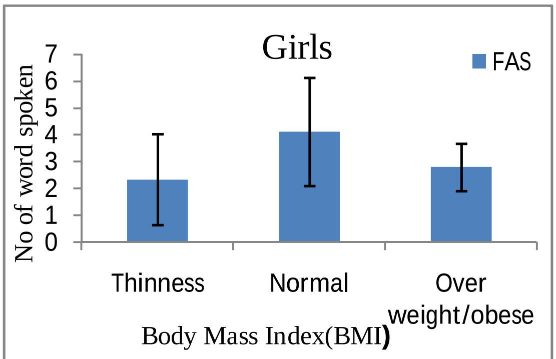


Fig- 36: Performances of phonemic fluency in variation to BMI.

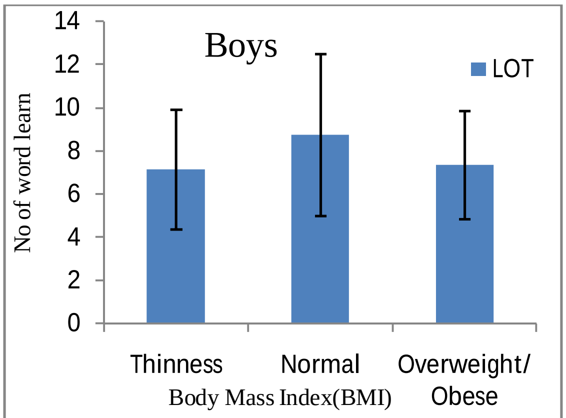


Fig-37: No of word learning in variation to BMI.

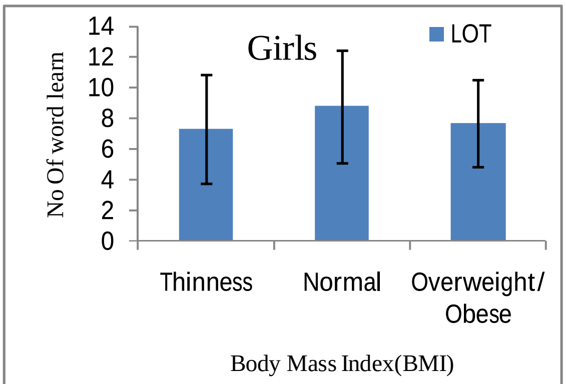


Fig-38: No of word Learning in variation to BMI

The correlation coefficient of cognitive variables with BMI of the children has been presented in Table 16. Results of correlation analysis demonstrated that BMI was significantly ($P<0.001$) and positively correlated with the scores of different cognitive skill variables such as, PCT, FAS, REC and LOT excepting CTT and CCT. The CTT and CCT were negatively and significantly ($p<0.001$) correlated with BMI. It may be mentioned that in case of the CTT and CCT the scores were expressed as time. Lesser time indicated better performance of the subjects. Therefore, it may be stated that the performance in these tests was positively correlated with BMI.

TABLE 16: Correlation coefficient of cognitive parameters with BMI of the primary school children

Cognitive parameters	Boy (n=445)	Girls (n=460)
Colour trail test (CTT)	-0.365***	-0.352***
Colour cancellation test (CCT)	-0.390***	-0.399***
Picture complitation test (PCT)	0.330***	0.368***
Fas phonemic fluency test (FAS)	0.415***	0.348***
Recognition (REC)	0.502***	0.425***
Learning of trials (LOT)	0.307***	0.210***

***p<0.001

The correlation coefficient of weight with different cognitive parameters of boys and girls were shown in Table 17. The same trends of results were noted as noted in case of BMI. It was revealed that the body weight of children had significant (p<0.001) and positive correlation with PCT, FAS, REC, and LOT.

TABLE 17: Correlation coefficient of cognitive parameters with body weight of the primary school children

Cognitive parameters	Boy (n=445)	Girls (n=460)
Colour trail test (CTT)	-0.490***	-0.525***
Colour cancellation test (CCT)	-0.475***	-0.543***
Picture complitation test (PCT)	0.469***	0.511***
Fas phonemic fluency test (FAS)	0.617***	0.592***
Recognition (REC)	0.736***	0.731***
Learning of trials (LOT)	0.423***	0.399***

***p<0.001

On the other hand, the CTT, and CCT were significantly (p<0.001) but negatively correlated with the body weight. As stated earlier in case of BMI, the performances of the subjects in tests of CTT and CCT were increased with lower values of body weight.

The linear regression of BMI with different cognitive parameters, such as, CTT, CCT, PCT, FAS, REC and LOT of both boys and girls were computed and that were presented in Tables 18 and 19. The results of regression analysis indicated that BMI had strong and significant association with different cognitive parameters (Tables 18 and 19) except CTT and CCT. Results also showed that BMI had negative and significant ($p<0.001$) association with CTT and CCT. Multiple regression analysis was performed after controlling for the effect of age, height weight, and socioeconomic status and it was demonstrated that the BMI had no significant impact on all the cognitive parameters. Therefore, the BMI might not be the best account for the variability of the cognitive performances.

Table 18: Regression analysis of BMI as independent variable with cognitive parameters as dependent variables (**Boys**)

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-8.18	0.960	-0.377	0.142	72.70	-8.527***	**0.158**	**1.762**	**0.007**	**0.9**
CCT	-9.21	0.981	-0.409	0.167	88.32	-9.39***	**-1.25**	**1.96**	**-0.056**	**-0.639**
PCT	0.141	0.018	0.351	0.123	61.68	7.85***	**-0.03**	**0.036**	**0.079**	**-0.818**
FAS	0.412	0.038	0.455	0.207	114.72	10.71***	**-0.023**	**0.072**	**-0.026**	**-0.327**
REC	0.62	0.051	0.50	0.25	151.75	12.31***	**0.159**	**0.081**	**0.129**	**1.86**
LOT	0.368	0.06	0.25	0.006	31.11	5.57***	**-0.10**	**0.13**	**-0.07**	**-0.78**

***$p<0.001$ # after adjusting age, weight, BMI, SES

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completation test. FAS -Fas phonemic fluency test. REC- recognition LOT-learning of trials]

Table 19: Regression analysis of BMI as independent variable with cognitive parameters as dependent variables (**Girls**)

Variables	Unadjusted						Adjusted#			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-9.90	0.986	-4.425	0.181	100.91	-10.04***	**-4.71**	**1.47**	**-0.202**	**-1.19**
CCT	-8.89	0.874	-0.429	0.184	103.52	-10.17***	**-2.95**	**1.32**	**-0.142**	**-1.23**
PCT	0.180	0.02	0.382	0.146	78.17	8.84***	**0.052**	**0.032**	**0.111**	**1.62**
FAS	0.347	0.045	0.341	0.117	60.42	7.77***	**-0.051**	**0.065**	**-0.050**	**-0.785**
REC	0.606	0.059	0.434	0.188	106.19	10.30***	**0.106**	**0.070**	**0.076**	**1.51**
LOT	0.305	0.075	0.187	0.035	16.58	4.07***	**-0.226**	**0.122**	**-0.139**	**-1.85**

***p<0.001 # after adjusting age,weight,BMI,SES

[CTT- colour trail test,CCT- colour cancellation test, PCT- picture completation test.FAS - Fas phonemic fluency test. REC- recognition LOT-learning of trials]

5.4.1.2. Discussion:

In the present study it was found that overweight / obese as well as thinness children had lower cognitive performance. In comparison to adequately nourished children, malnourished children with obesity and under nutrition showed poorer cognitive scores of attention and selective attention (colour trail test , CTT and colour cancellation test , CCT), visuospatial function (picture completion test , PCT) and executive function such as verbal fluency (phonemic fluency test , FAS) and verbal learning and memory (recognition , REC) and learning (LOT). A major increase in BMI predicted lower performance on lower cognitive test score.

It was found that under nutrition affects different cognitive characteristics of the children and the BMI was associated with the performance scores of the cognitive skills. Findings of this study were in conformity with other studies in which a strong association between BMI and the composite scores of cognition (Starman et al. 2008), memory (Gunstad et al. 2006), vocabulary (Kilandar et al. 1997) was noted. It may be mentioned that some studies found no association between thinness and measures of cognitive performances like memory, and verbal fluency (Kilandar et al. 1997). However, it was pointed out that a cumulative effect of thinness over time on cognition, which suggested the existence of other mechanisms. Thinness was the result of poor health (Losonczy et al. 1995); a further possibility was that thin persons experience a dysregulation in hormone secretion corresponding to that in anorexia, which results in cognitive disorders (Sabia et al. 2014).

A number of studies from high-income countries have related adult overweight/obesity to impair cognitive function (Elias et al. 2005). This could result from adiposity-related cardio-metabolic dysfunction, resulting in an impaired vascular supply to the brain (Gustafson 2012). However, several studies have now reported reduced cognitive function even in children in relation to overweight/obesity (Datar and Sturm 2005).

The majority of the studies showed that both adults and children with overweight/obesity were strongly associated with lower cognitive outcomes (Gunstad et al. 2007; Kamijo et al. 2012). Similar findings was found in the study with large group of children and adolescents between 8 and 16 years of age in the USA, showed that overweight children performed poorly in test measuring visuospatial function (Li et al. 2008). In other study in the USA showed that continuous measures of both BMI, and body fat measured using DEXA, in 7-9 year old children were negatively associated with scores in a ‘No Go’ task that requires inhibitory control (Kamijo et al. 2012). The study in Germany showed that among pre-school children aged 2-3 year, obesity was associated with reduced skill attainment (Mond et al. 2007). A prospective study in Spain showed that better cognitive performance at age 4 years, specifically executive function and verbal skills, was associated with a lower risk of being overweight at 6 years, suggesting that higher cognitive abilities in early life may prevent future risks of obesity in these children (Guxen et al. 2009). However, a study in the USA among children and adolescents aged 6-19 years found no association between higher BMI and cognitive functions (Veena et al. 2014).

Studies on animal model suggested that there might be a biological link between obesity and impaired cognitive performance that was related to insulin resistance and altered glucose metabolism (Jurdak et al. 2008). Higher values of BMI indicated overweight or obesity due to deposition fat in the body. It was found from the experiments that when rats were fed a high fat diet, it decreased neurogenesis in the hippocampus (Lindqvist et al. 2006). In addition, it was proposed that a maternal high-fat diet in mice altered the development of hippocampus in the foetus (Niculescu and Lupu, 2009) which might be mediated by a decrease in the level of brain-derived neurotrophic factor (Molteni et al. 2002). A recent literature review concluded that overweight and obesity might result in poorer academic performance (Burkhalter and Hillman, 2011), but only a few studies have researched a possible connection between obesity/overweight and cognitive performance. Li et al. (2008) described an association in 8–16-year-old children and adolescents between increased body mass index (BMI) and reduced cognitive performance, specifically visuospatial functioning as measured on the block-design test.

Some findings proposed by Cserje´ et al. (2007) established that obese children aged 12 years had worse cognitive flexibility and shifting ability than those of normal weight. In another study, Gunstad et al. (2007) showed that overweight/obese middle aged adults had reduced executive function performance compared with those of normal weight individuals.

It was also observed that a negative association persists in between higher verbal abilities and overweight. Verbal score is a proxy for crystallized intelligence. Crystallized intelligence depends on education that involves stimuli and concepts available to members of a cultural group, and is related to factual information (Boron 2004). Cawley et al. (2008) found that obesity was associated with reduced verbal skills in early childhood (age 2–3 years). An earlier cross-sectional study of children at age 5 years showed an unadjusted negative relation between crystallized intelligence and BMI (Azurmendi et al. 2005).

5.4.2 Effect of variation of BMI on motor performances of children

5.4.2.1 BMI and reaction time

5.4.2.1.1.Results:

The performance in the reaction time test of both boys and girls of different nutritional groups has been shown in the Table17. ANOVA was computed to find out the performances of reaction time test across the three different nutritional groups. The results showed that performances of normal weighed children was significantly better ($p<0.001$) than that of boys and girls of thinness and overweight groups. The post hoc analysis showed that the reaction time was longer in thinness and overweight boys and girl when it was compared with the reaction time of normal weighed children. From the Table 20 it was noted that the pattern of reaction time (RT) of boys and girls in variation to BMI has been presented in figures 39 and 40. The figures indicated that the performances in the reaction time was lower in the boys and girls belonged to normal weight status compared to that of boys and girls of thinness and overweight/ obese groups. Thus the findings represented that the reaction time of boys and girls was increased as BMI varies from thinness to normal or over weight to normal.

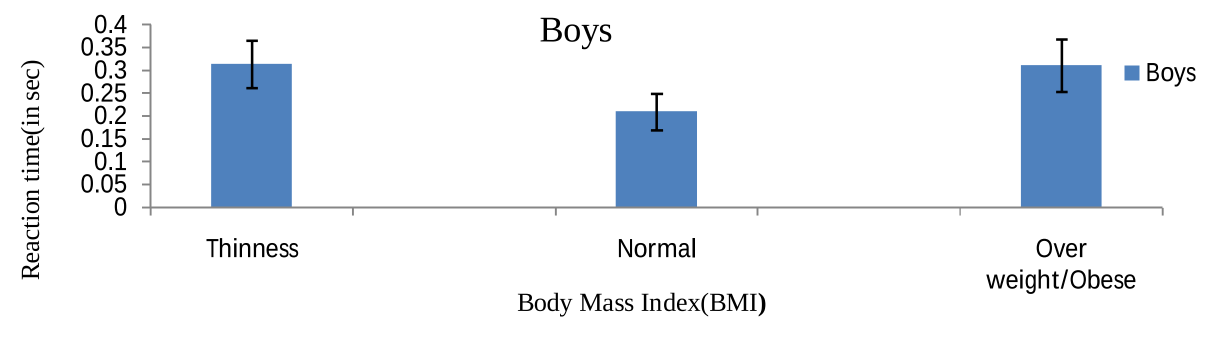


Fig-39:Reaction time in variation to BMI

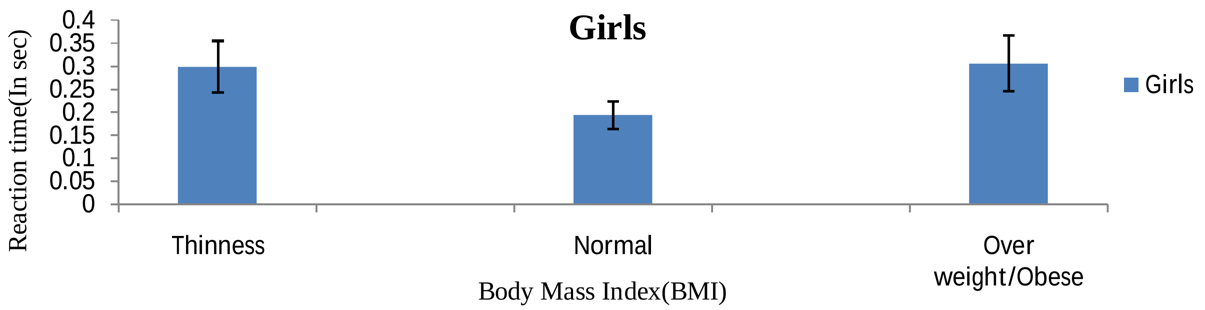


Fig-40: Reaction Time in variation to BMI

Table 20: Scores (Mean ±SD) of reaction time (in second) of boys and girls in three levels of nutritional status

Motor parameter	Thinness		Normal weight		Over weight / obase		F ratio	
Reaction time (in second)	BOY (n=112)	GIRL (n=122)	BOY (n=299)	GIRL (n=296)	BOY (n=34)	GIRL (n=42)	BOY	GIRL
	0.314 ±0.052	0.300 ±0.056	0.210***### ±0.04	0.194***### ±0.03	0.311 ±0.058	0.307 ±0.061	252.95$$$	256.25$$$

w.r.t. Thinness: * $p<0.05$, ** $p<0.01$, *** $p<0.001$, F ratio: $$$ $p<0.001$
w.r.t. over weight/ obase: # $p<0.05$, ## $p<0.01$, ### $p<0.001$

The correlation coefficient of BMI with the scores of reaction time of both boys and girls has been presented on the Table 21. The results demonstrated that BMI had significant negative correlation ($p<0.001$) with reaction time

Table 21: Correlation coefficient between reaction time and BMI

Gender	
BOY	GIRL
-0.507***	-0.415***

*** $p<0.001$

5.4.2.1.2.Discussion:

Reaction time can be defined as the time interval between the application of a stimulus and appearance of appropriate voluntary response by a subject (Gandhi et al. 2013). For example, how fast would a person react to apply breaks of a vehicle during driving or how quick would a person flee from a site of danger. The reaction time is the most importance in the field of sports where accurate precise decisions and coordinated movements would change the whole game scenario. The reaction time can therefore be said to reflect the integrity and processing ability of the central nervous system and hence can be used as a measure of cognition (Nikam 2012). The reaction time provides an indirect index of the processing capability of the CNS and a simple means of determining the sensorimotor performance (Lofthus 1981). There was growing evidence that overweight and obesity, indicated by body mass index, have been found to be associated with a host of medical conditions, like cardiovascular, pulmonary, and endocrine diseases. Neurophysiological studies have shown that BMI influenced cognitive function, attention and memory (Elias et al. 2003, Cournot et al. 2006). This provided a possible physiological explanation for BMI influencing reaction time. In the present study, it was found (Table 20) that reaction time of thinness and overweight/ obese children were longer when compared with the children of normal weight. Our findings were supported by other studies (Deore et al. 2012., Nene et al. 2011; Khan et al. 2015) which showed that the reaction time of thinness and overweight / obese was greater than that of normal children.

Overweight and obesity, indicated by the body mass index, were found to be associated with systemic diseases. Neurophysiological studies had shown that the brain regions that were involved in cognition, memory, vocabulary, speed processing and reasoning were influenced by BMI (Gunstad et al. 2006).

Simple reaction time evaluates the processing speed of CNS and the coordination between the sensory and motor systems (Esmaeilzadeh 2014). Reaction time measurement includes the latency in sensory neural code traversing a peripheral and central pathways, perceptive and cognitive processing, a motor signal traversing both central and peripheral neuronal structures and finally the latency in the end effectors activation (i.e., muscle activation) (Esmaeilzadeh 2014). So any change in reaction time indicates presence of a peripheral and/or central disturbance.

Graham and Henneberg, (2014) examined the association between markers of adiposity and neurological performance, inclusive of all body types. The investigators measured neuromuscular reaction time using a ruler drop test. This measure was served as a gross marker of peripheral and central neurological performance as both were needed to execute the reflex command. They showed a direct correlation of adiposity and malnourishment with neuromuscular reaction time. These findings indicated that body lipid reserves were integral to the development of the nervous system even amongst children within the healthy weight ranges. Their hypothesis was that the myelination of the nerves, both centrally through oligo-dendrocytes and peripherally by Schwann cells, was integral to that process as they were predominantly lipid. Amongst malnourished individuals, the somatic lipid reserves are modest. These fats may be minimally sequestered away for the development of myelin nerve sheath at the expense of saltatory conduction. This might account for the slowed neuromuscular reaction time demonstrated.

Previous studies had shown poor cognition in thinness children and it has been attributed majorly to preclinical dementia (Sabia et al. 2009). Another hypothesis that explained there was dysregulation in hormone secretion corresponding to that in anorexia (Sabia et al .2009).

In overweight subjects both visual as well as auditory reaction times were longer when compared with normal weight group, though the difference was not statistically significant. Similar study done by Skurvydas et al. (2009) showed longer reaction time in overweight subjects where they studied reaction time in young males.

Different neurophysiological studies have shown influence of obesity and elevated body mass index on cognitive functions, memory deficits and executive dysfunction in young as well as middle aged individuals (Gunstad et al., 2007; Skurvydas et al. 2009). This has been attributed mainly to obesity induced vascular disease. Other mechanism suggested that secretions of adipose tissue like hormones, cytokines, and growth factors affecting brain health (Sabia et al .2009). Thus it can be concluded that body mass index of an individual influences simple reaction time, which is an indirect measure of sensory-motor association.

5.4.2.2. BMI and Hand eye coordination of children

5.4.2.2.1.Results:

The performances of fine and gross motor dexterity and coordination skill, which was measured by Purdue peg board test, of the studied participants have been represented in Table 22, according to their pattern of nutrition. The subjects were divided into three nutritional groups according to the cut-off values of BMI, as mentioned earlier. The boys and girls, who had normal body weight, had better fine and gross motor dexterity and coordination in dominant, nondominant and both hands compared to thinness and overweight / obese subjects. The analysis of results (ANOVA) showed that there was a statistically significant variation in fine and gross motor dexterity and coordination among the children of three nutritional groups ($p<0.001$). The variables that showed statistical significance were analyzed further by post hoc test. The results showed that the students with normal weight had significantly greater peg board test scores ($p<0.001$) than that of thin boys and girls. The children of overweigh /obese group showed significantly lower peg board score (p<0.05 or lesser) compared to normal weighed children. However, no significant difference was observed in peg input score between the children of thinness and overweight / obese groups. Performances of pegboard score by dominant hand, non dominant hand of boys and girls has been presented in Table 22. Form the Table it was observed that the score of pegboard test of dominant hand ,non dominant hand and both hand of normal weight groups of boys and girls increased according to variation of BMI as shown in Figures 41-46. The figures indicated an alteration in the performance as the BMI varies.

Table 22: Scores (Mean ±SD) of Peg board test of boys and girls according to their nutritional status

Hand used for performing test	Thinness		Normal weight		Over weight / obese		F ratio	
	Boys (n=103)	Girls (n=107)	Boys (n=299)	Girls (n=289)	Boys (n=34)	Girls (n=35)	Boys	Girls
Peg board score of dominant hand	7.47 ±2.06	7.84 ±2.27	9.82 ±3.15 *** ###	9.69 ±2.48 *** ###	7.97 ±1.79	8.02 ±2.03	29.22 $$$	27.15 $$$
Peg board score of non dominant hand	6.63 ±1.86	7.31 ±2.36	8.74 ±2.63 *** ###	8.93 ±2.29 *** ##	6.8 ±2.43	7.75 ±2.46	34.05 $$$	20.60 $$$
Peg board score of Both hand	5.59 ±2.76	5.49 ±2.60	7.61 ±3.54 *** #	7.86 ±2.86 *** ###	6.05 ±2.96	5.94 ±1.51	23.54 $$$	33.30 $$$

F ratio: $$$ p<0.001 w.r.t. Thinness: * p<0.05, ** p<0.01, *** p<0.001,
w. r. t. over weight/ obese: # p<0.05, ## p<0.01, ### p<0.001

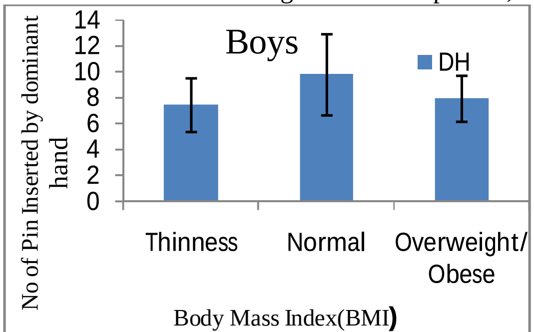


Fig-41: Performances of the score of pegboard test by dominant hand

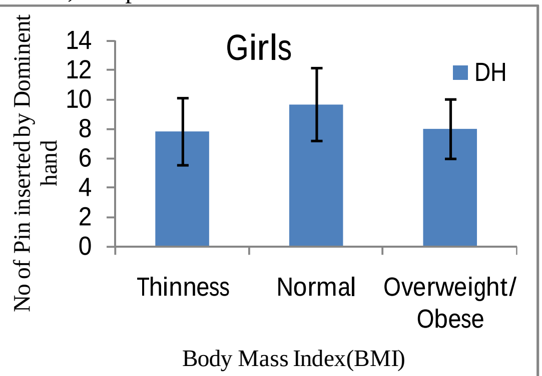


Fig-42: Performances of the score of Pegboard by dominant hand

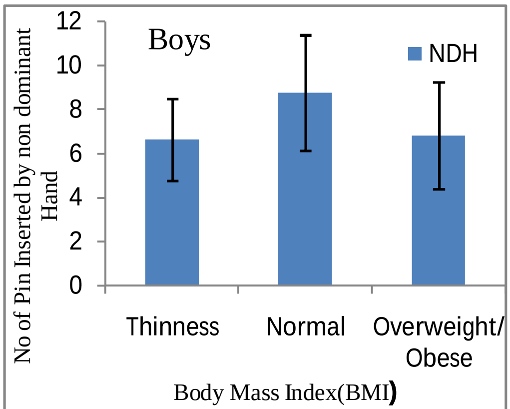


Fig-43: Performances of the score of pegboard test by non dominant hand in variation to BMI

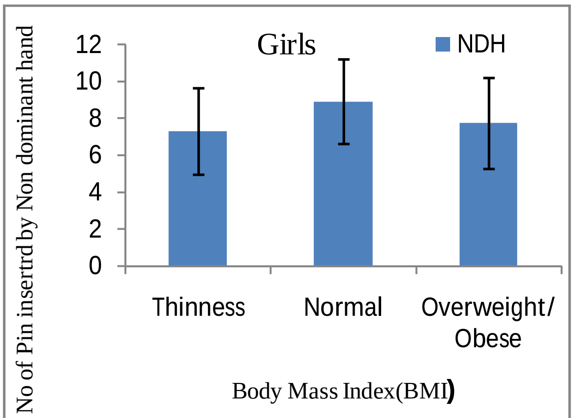


Fig-44:Performances of the score of Pegboard test by non dominant hand variation to BMI

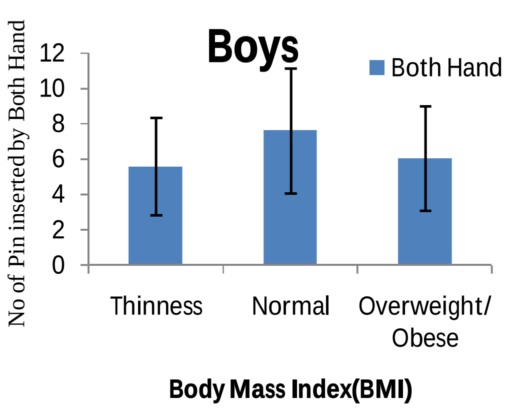


Fig-45:Performances of the score of Pegboard test by both hand variation to BMI

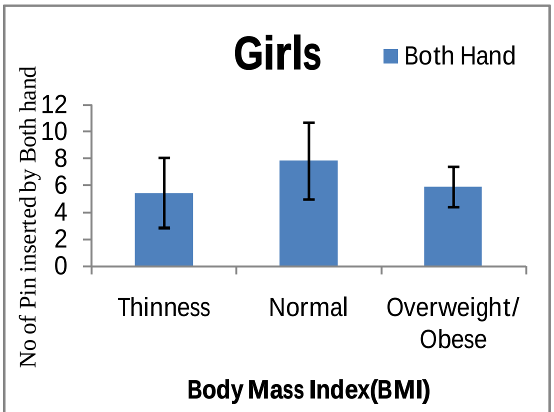


Fig-46: Performances of the score of Pegboard test by both hand in variation to BMI

The correlation coefficient of Purdue peg board score with BMI has been presented in the Table 23. The results of correlation coefficient demonstrated that the BMI had strong significant positive correlation ($p<0.001$) with the score of peg board test in dominant, non dominant and both hands.

Table 23: Correlation coefficient of peg board score of studied participant (all age groups) with BMI

Dominant hand		**Non dominant hand**		**Both hand**	
Boys	Girls	Boys	Girls	Boys	Girls
0.476 ***	0.353 ***	0.473 ***	0.348 ***	0.397 ***	0.341 ***

***p<0.001

In addition to BMI, the correlation coefficients of body weight of the children with score of the pegboard test were presented on Table 21A. From the results it was noted that the body weight of the children had significant positive correlation ($p<0.001$) with the scores of the pegboard test of dominant, non dominant and both hands.

Table 23 A: Correlation coefficient of body weight with peg board score of studied children of all age groups

Dominant hand		Non dominant hand		Both hand	
Boys	Girls	Boys	Girls	Boys	Girls
0.658***	0.632***	0.622***	0.656***	0.577***	0.565***

***p<0.001

Linear regression analysis of BMI with the score of different motor parameters were performed and result of regression analysis were presented in the Tables 24 and 25 for boys and girls respectively.

Table 24: Regression analysis of BMI as independent variable with motor parameters as dependent variables (Boys)

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
Reaction Time	-0.014	0.001	-0.502	0.252	147.86	12.16 ***	**-0.004**	**0.002**	**-0.148**	**-1.53**
Peg board score: Dominant Hand	0.552	0.050	0.46	0.219	123.04	11.09***	**-0.014**	**0.076**	**-0.034**	**-0.532**
Peg board score: Nondominant Hand	0.478	0.042	0.472	0.225	127.17	11.27***	**0.070**	**0.070**	**0.069**	**0.996**
Peg board score: Both Hand	0.549	0.059	0.407	0.165	87.11	9.33***	**-0.018**	**0.104**	**-0.014**	**-0.17**

***p<0.001 # after adjusting age, weight, BMI, SES

Table 25: Regression analysis of BMI as independent variable with motor parameters as dependent variables (Girls)

Variables	Unadjusted						Adjusted#			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
Reaction time	-0.012	0.001	-0.428	0.183	102.70	-10.13***	**-0.002**	**0.002**	**-0.078**	**-1.40**
Peg board score: Dominant Hand	0.422	0.049	0.372	0.138	73.52	8.57***	**0.092**	**0.061**	**0.081**	**1.50**
Peg board score: Nondominant Hand	0.378	0.047	0.352	0.124	64.87	8.05***	**0.051**	**0.057**	**0.047**	**0.890**
Peg board score: Both Hand	0.399	0.058	0.306	0.094	47.48	6.89***	**-0.049**	**0.083**	**-0.037**	**-0.582**

***p<0.001 # after adjusting age, weight, BMI, SES

The result showed that BMI had significant (p<0.001) association with different parameters such as reaction time (RT), peg board test scores of dominant hand, non dominant hand and both hands. In multiple regression analysis the effect of age height weight, and socioeconomic status was controlled and the results indicated that the BMI had no significant impact on the scores of RT and peg board test. Therefore, the BMI might not be the best account for the variability of the motor performances.

5.4.2.2.2.Discussion:

In this present study it was found (Table 22) that the scores of peg board test for dominant hand, non dominant hand and the both hands of overweight / obese children including both boys and girls were lower than that of the normal children. Our findings might be supported by the findings other investigations (Vamegi et al. 2013, D'Hondt et al. 2009., Dokic and Mededovic

2013 And Trutler et al. 2012) who also demonstrated that performances of fine motor skill in obese children was lower compared to the performances of children with normal weight.

It was observed from different studies that poorer motor competence in overweight or obese persons was generally believed to be the mechanical consequence of a greater inertial load on the system, caused by the excess mass of body segments participating in the action (O'Hue et al. 2009, Macgraw et al. 2000). The performance of obese children did not approach the level of the normal BMI-group. Although this could result from the mechanical demands related to the movement of the heavier-arm itself to place the pegs correctly into the peg board, it also put forward the idea that obese children might suffer from perceptual-motor coordination difficulties. The occurrence of poorer motor behaviour when sensory information was needed to plan and control the ongoing action was already suggested in obese children (Bernard et al. 2003).

Okely et al. (2005) stated that the performance of motor skill that required more motor components were difficult for overweight and obese children. It was also suggested that overweight and obese children faced more difficult to move their limb or larger body mass against gravity. In addition to this it was suggested that overweight and obese children were more likely to have orthopaedic changes such as flat feet, which may lead to greater pain when performed the motor skill or plays (Southall et al. 2004). For object control skills, the results of this research were consistent with the findings of Butterfield and co authors (Loovis et al. 2008, Butterfield et al. 2008). In this context, researchers reported that higher BMI had limited the range of motion in arms so that excess fat could also limit the movement in the shoulder and leads to poor performance in overweight and obese children (D’Hondt et al. 2009).

It was suggested that the body fat affected on body geometry and increased the mass of different body segments. Hence, non contributory mass could lead to biomechanical movement inefficiency and could be detrimental for motor proficiency (D'Hondt et al. 2009). On the other hand, the negative impact of BMI on fundamental motor skills can be explained by some other mechanisms. Overweight and obese children were often failure to perform the difficult activities. Thus, this might lead to a decreased regular physical activity and plays.

Previous studies have already shown that socioeconomic disparities could be related to obesity (Rosengren and Lissner 2008; Shrewsbury and Wardle 2008., Stamatakis et al. 2005). when performances of hand eye coordination of the children belonging to lower socioeconomic status was compared with the children of middle and upper socioeconomic groups, it was found that hand eye coordination of the children of the former group was poorer than the children of latter two groups (Table 45). Available data on this topic suggested that a low familial SES was an environmental risk factor for motor development, and especially for fine motor coordination (Bobbio et al. 2007, de Barros et al. 2003).

As children with movement difficulties perceived themselves less competent than other children, they were less likely to be physically active and they showed preference for sedentary pastime (Bouffard et al. 1996, Cairney et al. 2005, 2006). Such an activity deficit might however strengthen their lack of motor skill proficiency (Hands and Larkin, 2002). Withdrawal from physical activities surely inhibited diversified movement experiences and simultaneously opportunities promoting neuromotor development (Fisher et al. 2005; Wrotniak et al. 2006). At the same time, physical inactivity contributed to a positive energy balance and was therefore related to the current increase in childhood overweight and obesity (Abbott and Davies, 2004, Page et al. 2005, Hills et al. 2007). An inactive lifestyle thus might bring the obese child into a vicious circle, concerning both the health problem per se and the reported movement difficulties that seem to be related with it. Since earlier studies (Fisher et al. 2005, Graf et al. 2004, Wrotniak et al. 2006) demonstrated that physical activity was related to motor skill as well, it could be stated that children needed to be sufficiently physically active to experience movement in all its aspects. The occurrence of a tendency toward a weaker performance of obese.

5.5 Malnutrition and Cognitive skills and motor abilities

Part 4

Contents

5.5.1. *Effect of malnutrition on cognitive skills of the children*

5.5.1.1.Results:

Stunted growth reflects a process of failure to reach linear growth potential as a result of suboptimal health and/or nutritional conditions. Childhood stunting is a condition that is defined as height for age below the fifth percentile on a reference growth curve. The definition of stunting, according to the World Health Organisation (WHO), is for the "height for age" value to be less than two standard deviations of the WHO Child Growth Standards median.

In the present study the primary school children were subdivided into stunted and non-stunted (normal) on the basis of z score of the children.

It may be pointed out that the z score was calculated by following formula:

Z-score (or SD-score) = (observed value - median value of the reference population) / standard deviation value of reference population.

According to global database on Child Growth of World Health Organization (WHO), Z-score cut-off point of <-2 SD was classified as low height-for-age as moderate stunting . Z score cut off point and <-3 SD was defined as severe stunting (WHO 1983. 1995).

The frequency and percentage of stunted and non-stunted (normal) children of the studied population has been presented in Table 26. The result of the table showed that prevalence of stunting was very high; it was 35.05 % and 37.17 % respectively in boys and girls.

Table 26: Frequency (f) and percentage (%) of stunted and non-stunted boys and girls

		GROWTH STATUS	
		STUNTED	NON STUNTED
Boys (n=445)	f	156	289
	%	35.05	64.5
Girls (n=460)	f	171	289
	%	37.17	62.82

The cognitive skill parameters of stunted and non-stunted primary school children were studied separately and the results have been presented in Table 27. From the results it was noted that mean values of different cognitive parameters were higher in non-stunted group than that of stunted group in case of both male and female children. Data was analysed by t-test to compare the cognitive performances between two groups (Table 27). It was found that non-stunted children of both boys and girls performed significantly ($p<0.05$ or less) better than that of stunted children in cases of colour trail test and colour cancellation test (CTT, and CCT) , Picture completion test (PCT), verbal learning and verbal memory (REC, and LOT). In cases of CTT and CCT the mean values were significantly lower in non-stunted children indicating better performance as the scores were represented by means of time. However, mean values of other cognitive variables were significantly higher in non-stunted children than that of their stunted counterpart.

Table 27: Comparison of different cognitive parameters between stunted and non-stunted children

Cognitive parameters	Stunted group		Non-stunted group	
	Boys (n=156)	Girls (n=171)	Boys (n=289)	Girls (n=289)
Colour trail test (CTT)	127.32±63.15	122.55±62.12	103.30*** ±50.56	94.16*** ±45.82
Colour cancellation test (CCT)	130±56.36	121.25±57.78	111.9** ±59.50	96.25*** ±38.87
Picture complitation test (PCT)	3.31±1.08	3.43±1.14	3.74*** ±0.98	3.71** ±1.04
Fas phonemic fluency test (FAS)	2.88±2.02	2.92±1.93	3.79*** ±2.48	3.95*** ±2.5
Recognition (REC)	6.80±2.77	7.10±2.84	8.15*** ±3.31	8.48*** ±3.38
Learning of trials (LOT)	7.55±3.67	7.83±3.72	8.97*** ±3.65	8.75* ±3.83

w.r.t. Stunted group: * $p<0.05$, ** $p<0.01$, *** $p<0.001$, [CTT- colour trail test, CCT- colour cancellation test, PCT- picture completation test.FAS - Fas phonemic fluency test. REC- recognition LOT-learning of trials]

The correlation coefficient of different cognitive parameters with height has been presented in Table 28. It was noted that the scores of different cognitive parameters were significantly correlated with height (p<0.001).

Table 28: Correlation coefficients of cognitive parameters of studied participant with height

	Boys	Girls
Colour trail test (CTT)	-0.453***	-0.502***
Colour cancellation test (CCT)	-0.391***	-0.502***
Picture complitation test (PCT)	0.410***	0.442***
Fas phonemic fluency test (FAS)	0.533***	0.568***
Recognition (REC)	0.684***	0.698***
Learning of trials (LOT)	0.438***	0.419***

***p<0.001

However, the scores of CTT and CCT were negatively correlated with the height of both boys and girls which meant that the attention and selective attention of the children were improved with the increase of height of the children. Other cognitive variables were positively associated with the height of the boys and girls indicating betterment of cognitive characteristics, e.g., visuospatial function (PCT), Phonemic fluency (FAS), and verbal learning and memory (LOT, and REC), with the increment of height. Thus the result also showed that all the cognitive characteristics were improved with physical growth of the children.

The results of linear regression of height with the score of different cognitive variables of both boys and girls was presented in Tables 29 and 30. It was observed from the regression analysis that height had strong significant (p<0.001) association with the scores of different cognitive parameters. However, the results of multiple regression analysis showed that BMI had no significant impact on the cognitive variables when the effect of the age, weight, and socioeconomic scores were controlled. Therefore, the height might not be an influencing factor for the variability of the cognitive performances.

Table 29: Regression analysis of height as an independent variable and cognitive parameters as dependent variables (**Boys)**

Variables	Unadjusted						Adjusted #			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-2.80	0.263	-0.453	0.205	113.80	-10.66 ***	**-0.404**	**0.573**	**-0.065**	**-0.705**
CCT	-2.48	0.282	-0.387	0.150	77.73	-8.81 ***	**0.053**	**0.638**	**0.008**	**0.084**
PCT	0.047	0.005	0.408	0.187	88.13	9.38 ***	**-0.004**	**0.012**	**-0.033**	**-0.318**
FAS	0.137	0.010	0.532	0.283	173.28	13.16 ***	**-0.02**	**0.023**	**-0.016**	**-0.845**
REC	0.239	0.012	0.68	0.46	385.65	19.63 ***	**0.059**	**0.026**	**0.170**	**2.26**
LOT	0.17	0.017	0.43	0.19	104.18	10.20 ***	**0.05**	**0.04**	**0.132**	**1.26**

***p<0.001 # after adjusting age, weight, BMI, SES

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test. FAS - Fas phonemic fluency test. REC- recognition, LOT-learning of trials]

Table 30: Regression analysis of height as an independent variable and cognitive parameters as dependent variables (**Girls**)

Variables	Unadjusted						Adjusted#			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-2.60	0.209	-0.503	0.253	155.01	-12.45 ***	**-0.765**	**0.424**	**-0.148**	**-1.80**
CCT	-2.31	0.186	-0.502	0.252	154.31	-12.42 ***	**-0.419**	**0.380**	**-0.091**	**-1.10**
PCT	0.46	0.004	0.443	0.196	111.79	10.57 ***	**-0.013**	**0.009**	**-0.124**	**-1.40**
FAS	0.128	0.009	0.569	0.324	219.13	14.80 ***	**0.003**	**0.019**	**0.014**	**0.168**
REC	0.217	0.010	0.699	0.488	436.87	20.90 ***	**0.017**	**0.020**	**0.054**	**0.838**
LOT	0.152	0.015	0.419	0.176	97.72	9.88 ***	**0.032**	**0.035**	**0.001**	**0.009**

***p<0.001 # after adjusting age, weight, BMI, SES

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test , FAS - Fas phonemic fluency test, REC- recognition, LOT-learning of trials]

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The correlation coefficients of height for age with the amount of different nutrient consumption of the children were computed (Table 31). Results demonstrated that the height-for-age of the children was significantly (p<0.05 or less) correlated with different nutrient consumption values of the children.

Table 31: Correlation coefficient of height for age with nutrient consumption of the children (Boys and Girls)

	Carbohydrate	Protein	Fat	Calorie	Zinc	Choline	Omega 3 fatty acid
Height for age	0.572***	0. 89*	0.572***	0.620***	0.325***	0.499***	0.549***

*p<0.05,**p<0.01,***p<0.001

The correlation coefficients of different socioeconomic factors with dietary pattern of the children have been presented in Table 32. The results (Table 32) showed that all the socioeconomic factors were positively correlated (p<0.05 or less) with the amount of nutrient consumption of the children except the family size. Results showed that family size of the children were significantly and negatively (p<0.05 or less) correlated with the dietary consumption of the children.

Table 32: Correlation coefficient of different socioeconomic factors with nutritional status of the children

SES Factors	Carbohydrate	Protein	Fat	Calorie	Zinc	cholin	Omega 3 fatty acid
Family size	-0.439***	-0.076*	-0.401***	-0.362***	-0.303***	-0.497***	-0.475***
Family income	0.568***	0.079*	0.536***	0.482***	0.337***	0.601***	0.567***
Parental occupation	0.580***	0.089*	0.525***	0.502***	0.323***	0.591***	0.580***
Parental years of Education	0.566***	0.094**	0.565***	0.484***	0.333***	0.654***	0.616***

*p<0.05,**p<0.01,***p<0.001

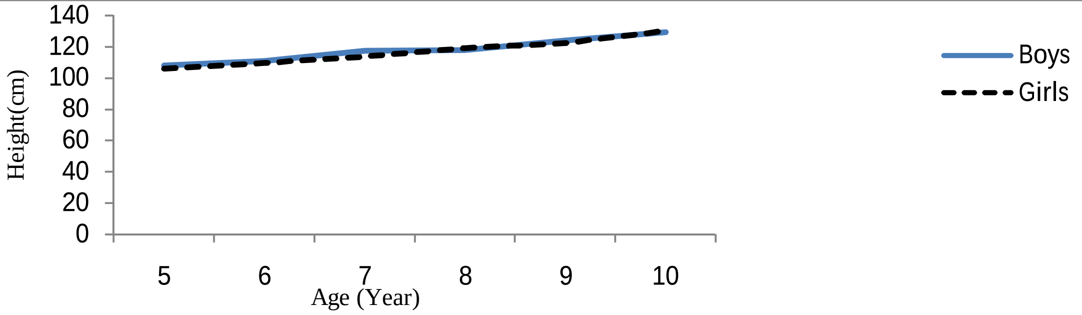

Fig-47: Height of boys and girls as a fuction of age

Variation of height of boys and girls as a function of age has been presented in Fig-45. The Figure revealed that pattern of increment of height of boys and girls was more or less similar and gradually increased with the increase of age.

5.5.1.2. Comparison of growth pattern of cognitive skills in between stunted and non stunted children.

The comparison of growth pattern of different cognitive skills in between stunted and non stunted children has been presented in figures 48 - 59. From the figures it was noted that the growth curve of the Colour trail test (CTT) and colour cancellation test (CCT) of non-stunted boys and girls remained in the lower side in comparison to that of stunted children (Figs 48-51). As these cognitive parameters were expressed in time, the growth of these cognitive parameters (attention) was better in non-stunted children than that of stunted children.

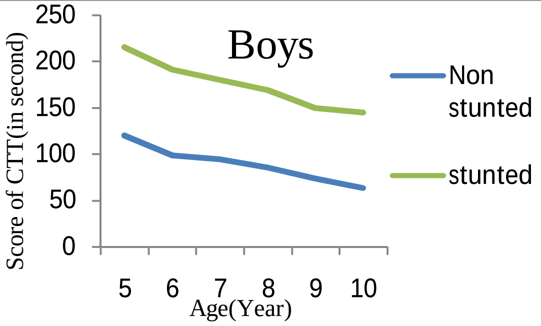

Fig-48: Comparison of growth pattern of colour trail test between stunted and non -stunted boys.

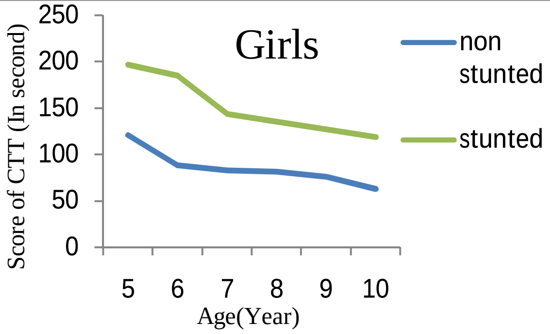

Fig-49: Comparison of growth pattern of colour trail test between stunted and non-stunted girls.

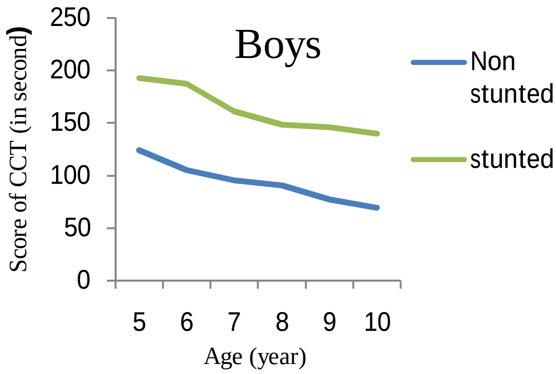

Fig-50: Comparison of growth pattern of colour cancellation test between stunted and non stunted boys.

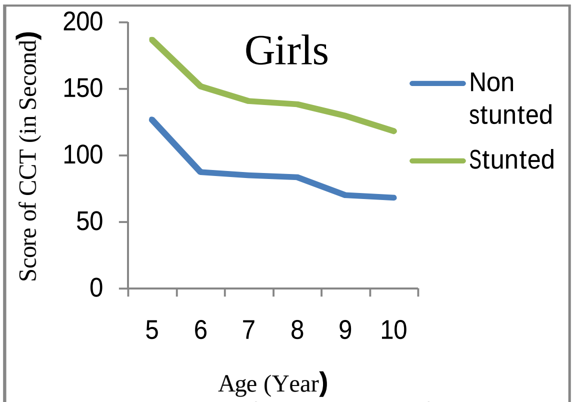

Fig-51: Comparison of growth pattern of colour cancellation test between stunted and non stunted girls.

The growth curve of the picture completion test (PCT) in stunted children was positioned in the lower side of the scale in comparison to that of non-stunted children indicating lower growth in this cognitive parameter in the former group (Figs. 52- 53). Thus the findings revealed that retardation in physical growth in case of stunted children also caused a hindrance in cognitive growth.

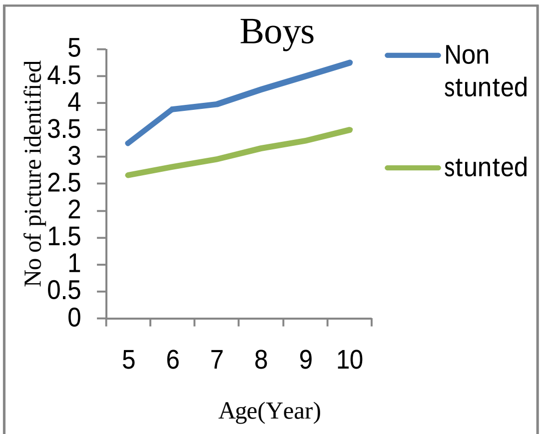

Fig-52: Comparison of growth pattern of Picture completion test between stunted and non stunted boys.

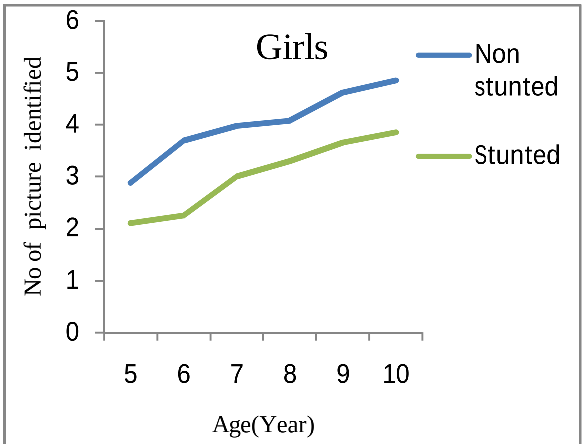

Fig-53:Comparison of growth pattern of Picture completion test between stunted and non stunted girls.

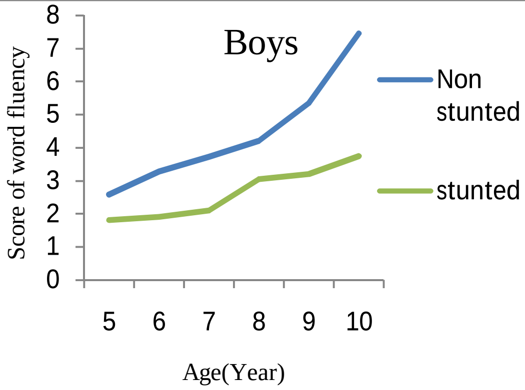

Fig-54:Comparison of growth pattern of phonemic fluency test between stunted and non stunted boys.

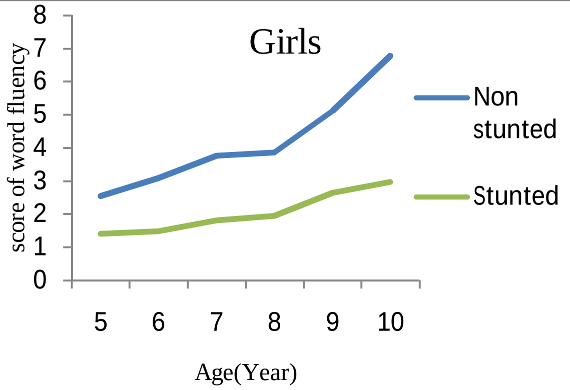

Fig-55: Comparison of growth pattern of phonemic fluency test between stunted and non stunted girls.

The growth curve of the phonemic fluency (FAS) showed a remarkable difference between the stunted and non-stunted children. The non-stunted (normal) children had better growth in phonemic fluency than that of stunted children (Figs. 54-55).

The growth curves of other cognitive parameters have been presented in Figs. 56 to 59. It was observed that the growth curves of the recognition (REC) and learning (LOT) of the non-stunted children was found to be higher with the increment of the age related height of the children. The non-stunted children showed better development of height than that of stunted children; better cognitive growth was also observed in case of non-stunting children.

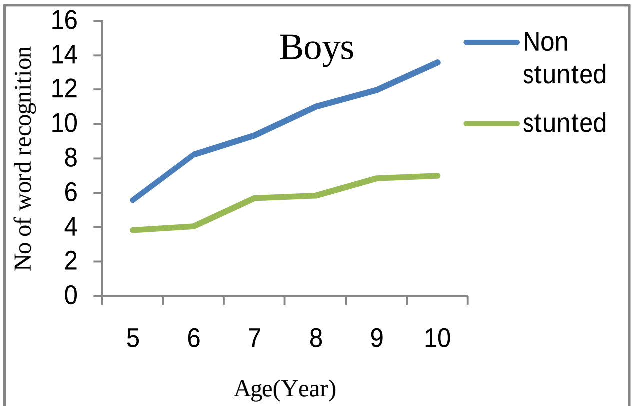

Fig-56: Comparison of Growth pattern of recognition of word in between stunted and non stunted boys.

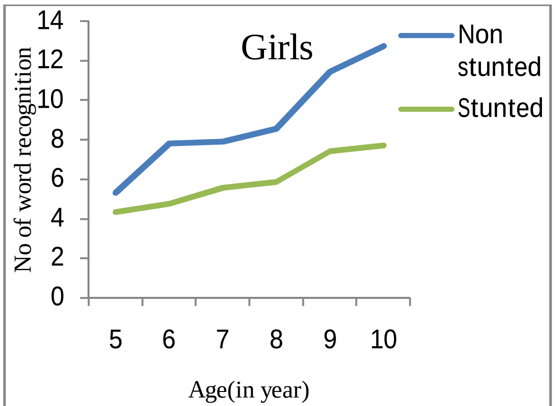

Fig-57:Comparison of Growth pattern of recognition of word in between stunted and non stunted girls.

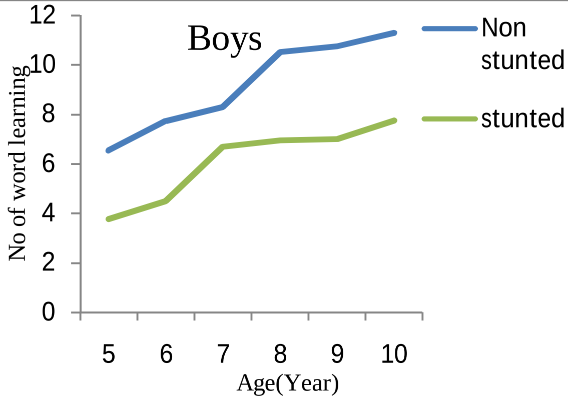

Fig-58: Comparison of Growth pattern of word learning in between stunted and non stunted boys.

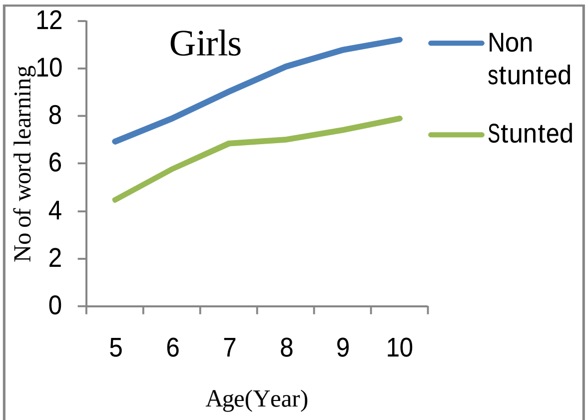

Fig-59 : Growth pattern of word learning in between stunted and non stunted girls.

5.5.1.3.Discussion:

A good nutritional status can improve the cognitive development of an individual. Poverty and malnutrition form a vicious cycle. Poverty prevents individuals to access good nutrients sources. For example, meat, fishes and animal foods sources are very rich in bio available minerals, but it is very inaccessible to poor population. They are forced to consume mainly vegetal foods that contain many anti nutritional substances that inhibit micronutrients bioavailability and sometimes micronutrients digestibility. Illiteracy is another underlying factor of poor feeding (Warsito et al. 2012).

The findings of our present study can be discussed in terms of the effect of chronic malnutrition on cognitive skills. It is an established fact that poor nutrition may lead to stunted physical growth of the children. Results of the present study (Table 27) indicated that the test performances of malnourished children with stunted growth were poorer in most of the cognitive tests compared to that of adequately nourished children. It was found (Table 27) that malnourished children had poor performance on tests of higher cognitive functions like, cognitive attention, working memory, visual perception, verbal comprehension, and memory. These findings may be supported by other studies on Indian malnourished children, which reported memory impairments in undernourished children (Agarwal et al. 1995., Kar et al. 2008) and they also showed poor performance on novel tasks like, tests of executive functions. Poor performance on most of the cognitive tests indicated a diffuse impairment including attention, executive functions, visuospatial functions, comprehension and memory. On comparison of cognitive skill between malnourished children with stunted growth and adequately nourished children, it was found that malnourished children performed lower score than the adequately nourished children and showed impairment of cognitive skill in malnourished children.

It was found that the executive function such as attention (CTT, CCT) were deficient in malnourished children. All the three tests of executive functions like fluency, selective attention required cognitive flexibility as well as faster information processing which was affected in malnourished children (Kar et al. 2008).

It was noted form the present study that visuo-spatial functions (PCT)showed poorer performance when compared to the adequately nourished children. Kar et al. (2008) reported that performance on functions like visual perception (visual discrimination, perceptual matching, visual closure and visuospatial relationships and visual construction) was severely affected in malnourished children.

Verbal learning and verbal memory of malnourished children were found to be poorer compared to adequately nourished children. Kar et al. (2008) suggested that impairment of ability of comprehension and verbal learning and memory in malnourished children. The author also reported that the visual memory was most severely affected in malnourished children in terms of the poor performance on delayed recall on the test found when compared the performances between stunted and non stunted groups.

Similar studies were also observed in other than Indian population. Grantham and Gregor ,(1995) also reported that school-age children who suffered from early childhood malnutrition had generally been found poorer IQ levels, cognitive function, school achievement and greater behavioural problems compared to adequately nourished children. The disadvantages last at least until adolescence.

From the neuropsychological interpretation of Lavitski et al. (1995) it was revealed that cognitive processes were more severely affected in malnourished children than adequately nourished children that suggested a diffuse cortical involvement. This was with reference to deficits pertaining to functions mediated by dorsolateral prefrontal cortex which associated with poor performance on tests of attention, fluency and working memory and right parietal associated with poor performance on tests of visuospatial functions and bilateral temporal cortex involved in poor performance on tests of comprehension, verbal learning, and memory for verbal and visual material. Lavitski et al. (1995) also reported that the prefrontal cortex was particularly vulnerable to malnutrition. Udani et al. (1995) reported that the adverse effects of malnutrition (PEM-stunting) on cognitive development could be related to the delay in certain processes of structural and functional maturation like delayed myelination and reduced overall development of dendritic arborisation of the developing brain.

Family size of the children was an important factor for the development of cognitive function of the children. In this present study it was found that family size of the children was significantly correlated with their nutritional status. Emel et al. (2005) stated that the number of children and the family size were the important factors for malnutrition. Household size has a very big influence on young children nutritional state. There was therefore competition on the household's financial resources which could affect the nutritional status of children living in poorest families.

In the present study it was found that parental education was significantly correlated with the dietary pattern of the children. Similarly, educational level of mothers was very important especially when living conditions were difficult. The different study proved that the length of mother’s education affected the cognitive development of the children. It was indicated that higher was the mother education able to improve cognitive development of their children (Madginzira 1995., Sardjunani and Salio, 2006). It was also reported that high level of mother's education might provide the opportunity for accessing article, news paper, magazine to understand the knowledge about nutritious food and thus influenced normal cognitive development of the children (Hastuti et al. 2009., Warsito et al. 2012).

It was found from results that malnourished children had much lower score than adequately nourished children in all aspects of cognitive performances. In the present study it was found that height of the children was significantly correlated with nutritional status of the children. This finding may be supported by previous studies which indicated that there was significant relationship between nutritional status that based on the height with mental development of children (Anwar 2002) and other studies revealed that malnutrition suffered by the child at early age that had an effect on physical growth and brain development (Martorell 1995 and Grantham et al. 1999).

Djeukeu (2013) reported that the stunted children had poor school result as they were usually ill. Malnourished children tend to start school later, progress less rapidly, had lower attainments, and perform less well on cognitive achievement tests, even into adulthood. The author also suggested that indirect effects of malnutrition on productivity were substantially more than the direct effects of height on schooling and hiring. Djeukeu (2013) reported that malnourished children may receive less education than their well-nourished peers for a number of reasons. Caregivers may invest less in their education or schools may use physical size as a rough indicator of school readiness, and thus bar children of short stature from entering school at the appropriate age. Malnourished children are also sick more often and so absent more often, and learn less well when they are in school.

5.5.2. Effect of malnutrition on motor abilities of the children

5.5.2.1. Malnutrition and reaction time in children

5.5.2.1.1. Results:

The correlation coefficient between height and reaction time has been presented in Table 33. From the results it was noted that reaction time of both boys and girls was inversely correlated with height (p<001) indicating better performance of the participants with the increment of height.

Table 33: Correlation coefficient of reaction time of with height of the primary school children

Boys	Girls
-0.550***	-0.546***

***p<0.001

The results of linear regression analysis of height with the score of reaction time (RT) of girls and boys have been presented on Tables 34 and 34A respectively. In regression analysis height was an independent variable and the scores of RT was dependent variable. The results of regression analysis revealed that height was strongly associated with score of RT. Multiple regression analysis of height demonstrated that height had no significant impact on score of reaction time of boys and girls when the effect of age, weight, BMI, SES was controlled.

Table 34: Regression analysis of height as independent variable and reaction time as a dependent variables (girls)

Variable	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
Reaction time (Sec)	-0.003	0.000	-0.545	0.297	193.28	-13.90 ***	-0.001	0.000	-0.155	-1.71

***p< 0.001 # after adjusting age, weight, BMI, SES

Table 34A: Regression analysis of height as independent variable and reaction time as dependent variables (boys)

Variable	Unadjusted						Adjusted#			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
RT (Sec)	-0.004	0.000	-0.55	0.303	190.97	-13.81***	-0.001	0.001	-0.07	-0.94

***p< 0.001 # after adjusting age, weight, BMI, SES [RT- Reaction time]

The scores of reaction time of boys and girls of primary schools have been presented in Table 35. It was noted that the children of the normal group (non-stunted) had significantly lesser score ($p<0.05$ or lesser) than that of stunted group indicating better reaction time in non-stunted children.

Table 35: Comparison of reaction time between stunted and non-stunted boys and girls

Motor parameter	Stunted Children		Nonstunted Children	
	Boys (n=156)	Girls (n=171)	Boys (n=289)	Girls (n=289)
Reaction time (Sec)	0.313±0.050	0.294±0.057	0.211***±0.044	0.197***±0.039

W.r.t. Stunted gr * p<0.05, ** p<0.01, *** p<0.001,

5.5.2.1.2. Comparison of growth pattern of reaction time between stunted and non-stunted children

The growth curve of reaction time of boys and girls were presented in Figs. 60 and 61 respectively. It was noted that the growth of reaction time of non-stunted boys and girls was found to be higher than that of stunted children.

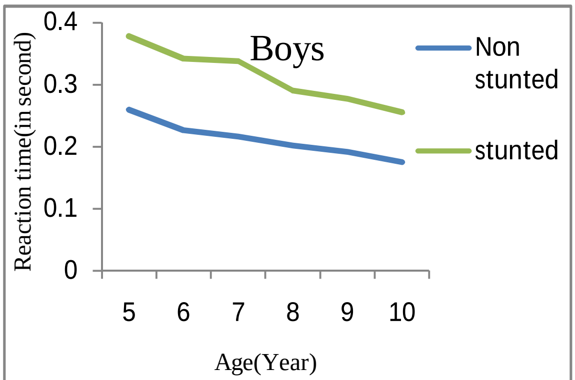

Fig-60: Growth pattern of reaction time in between stunted and non stunted boys.

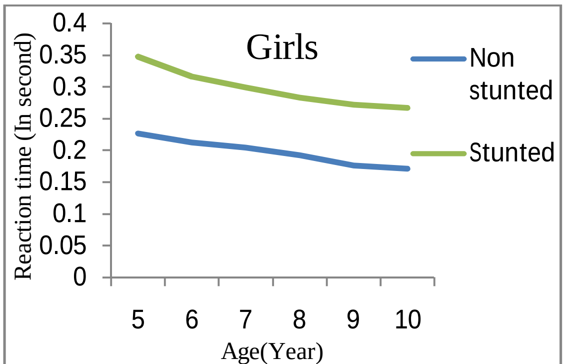

Fig-61: Growth pattern of reaction time in between stunted and non stunted girls.

5.5.2.1.3.Discussion:

The result of the present study (Table 35) showed that reaction times of malnourished children were longer in all ages compared to their normal counterpart. Thus the growth curve of reaction time of stunted children remained in the upper side in comparison to that of normally nourished children. So it represented that stunted children had poorer growth of reaction time test than that of normal children. The reaction time includes the latency in the sensory neural code which traversed from the peripheral to the central pathways, the perceptive and the cognitive processing, a motor signal which traversed both the central and the peripheral neuronal structures and finally, the latency in the end effecter activation i.e. the muscle activation (Esmaeilzadeh 2014). Many studies have focused on the detrimental effects of malnourishment to the performance of the brain and peripheral nerves. Malnourished children and adults have been studied extensively to establish these consequences.

The result of our study was in conformity with cross sectional studies made by Namita et al. (2010) and TA et al. (2011) who reported that performances of reaction time in malnourished children was lower than adequately nourished children. The researcher explained that the lower performance of reaction time was due to involvement of some chemical changes that occurred in our central nervous system. Greater delay in neuromuscular transmission of malnourished children during performances of task of reaction time compared to adequately nourished children was reported (Namita et al. 2010). Delayed neuromuscular transmission in malnourished children might be the cause of lower growth of reaction time in malnourished children.

Gustafson (2006) observed that in the elder children, the association between underweight and the cognitive functions was likely to be the result of a preclinical dementia. In this study the author showed that performances of reaction time test were lower compared to adequately nourished children. The malnutrition could be a result of poor health. A further possibility was that the malnourished persons experience a dysregulation in the hormone secretion which correspond to that in anorexia, which resulted in motor dysfunction

5.5.2.2 Effect of Malnutrition on hand eye coordination and manual dexterity

5.5.2.2.1.Results:

The scores of pegboard test in malnourished and adequately nourished children have been presented in Table 36. The results showed that the scores of pegboard test of dominant, non-dominant and both hands were significantly lower ($p<0.001$) in malnourished groups of both sexes compared to that of adequately nourished children. In other words, the adequately nourished children had significantly better motor performances like, hand eye coordination and manual dexterity than that of malnourished children.

Table 36: Comparison of scores of peg board test between stunted and non-stunted boys and girls

Motor parameter	Stunted Children		Non-stunted Children	
	Boys (n=156)	Girls (n=171)	Boys (n=289)	Girls (n=289)
Peg board score of dominant hand	8.46±2.61	8.45±2.50	9.73*** ±3.19	9.65*** ±2.62
Peg board score of non-dominant hand	7.50±2.41	7.83±2.28	8.68*** ±2.62	8.92*** ±2.53
Peg board score of Both hand	6.07±2.96	6.38±2.86	7.87*** ±3.62	7.73*** ±3.01

w.r.t. Stunted group * $p<0.05$, ** $p<0.01$, *** $p<0.001$,

The correlation coefficients of height with peg board test scores have been presented in Table 37. It was noted that height had significant ($p<0.001$) positive correlation with the peg board score in all combination of hands.

Table 37: Correlation coefficient of height with pegboard score of primary school children

Dominant hand		Non dominant hand		Both hand	
Boys	Girls	Boys	Girls	Boys	Girls
0.608***	0.648***	0.572***	0.680***	0.55***	0.564***

***$p<0.001$

Linear regression analysis of height with the scores of peg board test of both boys and girls was presented in Tables 38 and 38A respectively. From the results it was noted that height was significantly ($p<0.001$) associated with score of peg board test in all combination of hand. Multiple regression analysis demonstrated that after adjustment the effect of age weight, BMI, and SES, the height had no significant effect on the score of pegboard test of boys and girls. Therefore height cannot be said as a confounding factor for the motor performance of the children.

Table 38: Regression analysis of height as independent variable and motor parameter (pegboard score) as dependent variables (**Boys**).

Variables	**Unadjusted**						**Adjusted #**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
DH	0.20	0.013	0.603	0.364	251.96	15.87***	**-0.01**	**0.025**	**-0.04**	**-0.537**
NDH	0.163	0.011	0.568	0.322	208.86	14.45***	**0.021**	**0.023**	**0.074**	**0.933**
BOTH HAND	0.210	0.015	0.547	0.299	188.04	13.71***	**0.04**	**0.034**	**0.105**	**1.18**

*p<0.001 # after adjusting age, weight, BMI, SES

[DH- Dominant Hand, NDH-Non dominant Hand, SES- Socioeconomic status, BMI- Body Mass Index]

Table 38 A: Regression analysis of height as independent variable and motor parameter (pegboard score) as dependent variables (Girls)

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
DH	0.164	0.009	0.649	0.421	332.51	18.23***	**0.019**	**0.018**	**0.075**	**1.08**
NDH	0.162	0.008	0.068	0.464	395.83	19.89***	**0.026**	**0.016**	**0.110**	**1.60**
BOTH HAND	0.163	0.011	0.564	0.318	213.84	14.62***	**-0.001**	**0.024**	**-0.003**	**-0.039**

***p<0.001 # after adjusting age, weight, BMI, SES

[DH- Dominant Hand, NDH-Non dominant Hand, SES- Socioeconomic status, BMI- Body Mass Index]

5.5.2.2.2.Comparison of Growth of hand eye coordination between stunted and non-stunted groups

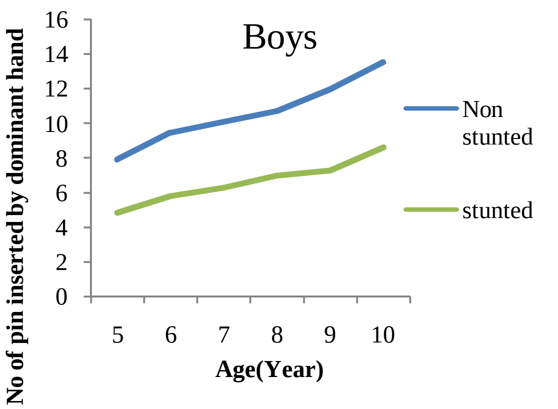

Fig-62: Growth pattern of pegboard score (hand eye coordination) by dominant hand in between stunted and non stunted of boys.

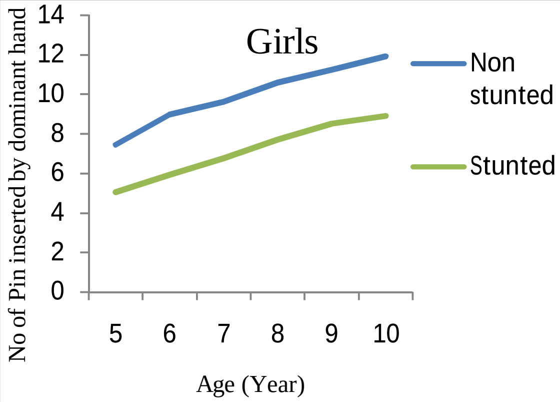

Fig-63: Growth Pattern of pegboard score (hand eye coordination) by dominant hand in between stunted and non stunted girls.

Figure 62 and 63 represents the growth curve of hand eye coordination (score of pegboard test) by dominant hand of the children of stunted and non stunted boys and girls respectively. It was observed that the growth of hand eye coordination of the non-stunted children, in case of the test with dominant hand was comparatively higher than that of the stunted boys and girls. The said growth curve of the normal children remained upper side of the curve found in the stunted children.

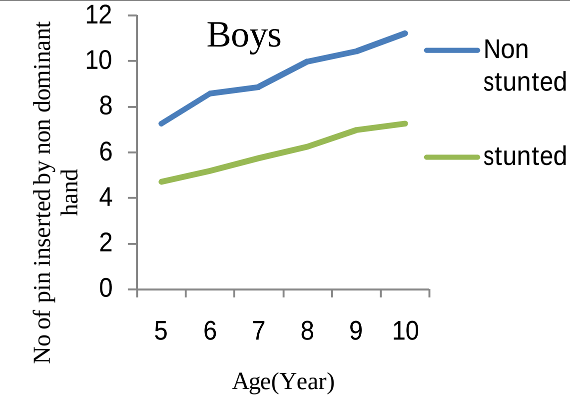

Fig-64: Growth pattern of pegboard score (hand eye coordination) by non-dominant hand in between stunted and non stunted boys.

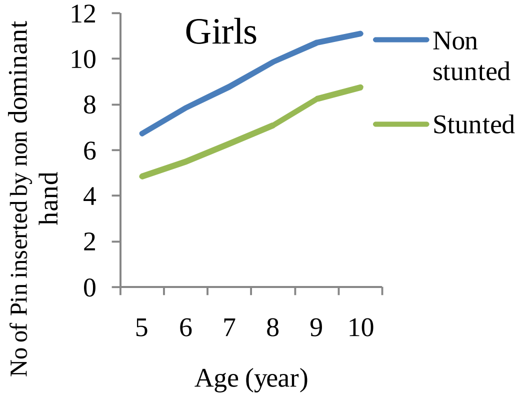

Fig-65: Growth Pattern of pegboard score (hand eye coordination) by non-dominant hand in between stunted and non stunted girls.

The growth curves of hand eye coordination, in cases of testing with non dominant hand as well as both hands have been presented in Figs. 66 – 67 for boys and girls. In both the cases the growth was better in normal children in comparison to stunted children.

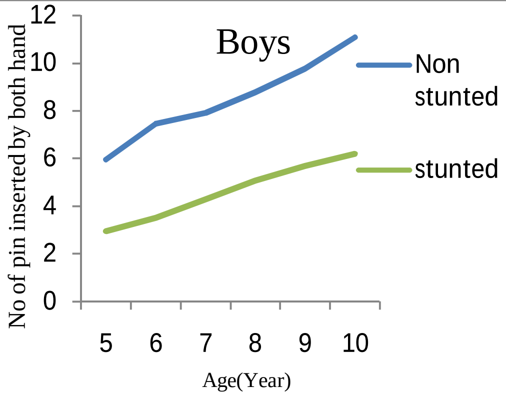

Fig-66: Growth pattern of pegboard score (hand eye coordination) by both hands in between stunted and non stunted boys.

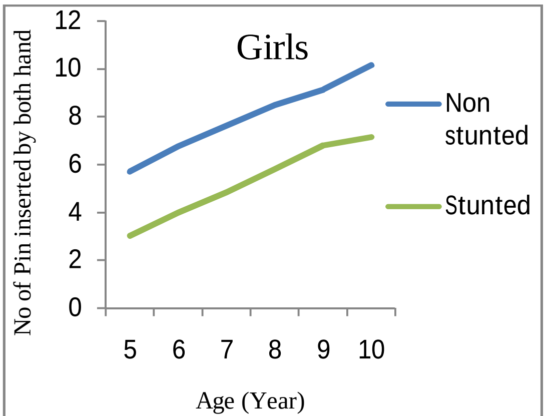

Fig-67: Growth Pattern of pegboard score (hand eye coordination) by both hands in between stunted and non stunted girls.

5.5.2.2.3.Discussion:

The findings of the present study (Table 36) revealed that the performance of Purdue peg board test of stunted children was lower than boys and girls of adequately nourished (non-stunted) children. The growth of the hand eye coordination was also lower in stunted children than that of non-stunted children. Our findings were in conformity with other studies performed by Chang et al. (2010) and Wekulo et al. (2013) who also demonstrated that motor performance level of malnourished children was lower than adequately nourished children. These findings suggested that nutritional insults in early childhood were associated with subtle changes in brain development in areas that control certain fine motor functions, and these effects were evident several years after the period of under nutrition. Mostofsky (2009) used functional magnetic resonance imaging of the children who was suffering from autism and showed that sequential oppositional finger tapping was related to activity in cortical and sub cortical regions that was associated with motor execution, including the contra lateral primary sensorimotor cortex, the contra lateral thalamus, ipsilateral cerebellum, and supplementary motor area. They also showed that the children with autism had slower rate of finger tapping and reduced activation of ipsilateral anterior cerebellum, and greater activation in the supplementary motor area. It was possible that the malnourished children also had changes in brain function of these areas.

In this present study it was found that co-ordination of hand and eye was decreased in the malnourished children compared to adequately nourished peer. Earlier, Griffith (1967) demonstrated that malnourished children had significantly lower developmental quotients and lower scores on all measured subscales (locomotor, hand and eye coordination, hearing and speech performances) than the non-stunted children, and the deficit increased over the 2 years. Gramsbergen (2003) reported that the cerebellum was linked to motor coordination and fine adjustments to muscle tone.

The immediate causes of malnutrition are due to inadequate food intake (in terms of quantity or quality) and diseases. However, malnutrition is influenced by a host of underlying factors related to poverty, including food insecurity, poor water, sanitation and health services, which find their roots in factors that can vary from conflict to climate change; from scarce natural resources to high and volatile food prices; from poor governance to demographic growth (Robert 2008).

Children with PEM showed lower motor performance which could be due to early nutritional insults to the developing brain. Different literature also suggested that the long-term effects of under nutrition in infancy can be associated with reduced motor abilities during childhood and adolescence (Bartel et al. 1978., Darrah et al. 1998). Children with poorer nutritional status aged 5-10 years showed lower motor performance compared to well nourished children and reported lower socio-economic status and poorer nutritional status as few contributing factors for lower motor proficiency in malnourished children (Dutta et al. 2010). The findings of our study were similar to this report in terms of lower motor performance of children with nutritional deficiency.

Under nutrition may influence brain development by directly affecting brain processes or indirectly by affecting children's experiences and behaviour. First, inadequate availability of nutrients during gestation and infancy affects the structural and functional development of the brain. Gestation and infancy are periods of rapid brain development. The neural tube begins to form 16 days after conception and within 7 months takes on a form that resembles the adult brain (Couperous and Nelson, 2006).Nutrients are required for many of the biological processes that drive this transformation, e.g., the formation of synapses, and the covering of axons with myelin, which is fatty matter that accelerates the speed of nerve impulses travelling from one cell to another. Inadequate availability of energy, protein, fatty acids, and micronutrients impairs these neural developmental processes (Georgieff and Rao, 1999). These nutrients are also important for brain function throughout childhood and adulthood, for example, for the maintenance of brain tissue and for neurotransmitter synthesis (Beard 2003., Pollitt 1993). Wallingford et al. (1980) showed that protein malnutrition on different cerebellar cell types include delayed cerebellar neurogenesis. Malnutrition results loss of granular cell (Clus et al. 1977) and aberrant Parkinjee cell (PC), dendritic arborisation (Chen and Hillman, 1980) occurred. Calbindin protein expression in perkinjee cell depends on intake of protein in nutrition (Baimbridge et al. (1982). This protein was responsible for fine motor coordination (Baimbridge et al. 1982). In protein malnutrition there was less synthesis of calbindin protein in parkinjee cell as well as decrease in the cell volume of parkinjee cell and granular cell layer resulting disturbances of fine motor activity. The brain change produced by early malnutrition, which was more severe in nature, was evident only during or immediately after a period of malnutrition was reported by Ranade et al. (2011). These defects in most cases were found to be reversible (Ranade et al. 2011).

5.6 Socioeconomic status and cognitive skills and motor abilities of children

Contents

5.6.1. Effect of variation of socioeconomic status on cognitive skills of primary school children.

Assessment of socioeconomic status (SES) of a person or a population is an important aspect in community based studies because it is an important determinant of health and nutrition of an individual. Assessment of SES of a family would mean categorization of the family in respect of different variables such as, education, occupation, economic status, etc. In the present study the socioeconomic status of the primary school children was assessed by modified Kuppuswami scale (Chhabra and Sodhi,2012) considering the literacy level, occupation and economic condition and was expressed in terms of literacy level and socioeconomic status. The children were divided into three socioeconomic groups, viz., lower, middle and upper according to the norms of Kuppuswami scale.

The frequency and percentage of socioeconomic status of primary school children was presented in Table 39. It was shown that out of 445 boys about 34.38 % , 26.96 % and 38.65 % of male children were belonging to lower, middle and upper socioeconomic status respectively. On the other hand, out of 460 girls about 30%, 28.91 % and 41.08 % girls were belonging to lower, middle and upper socioeconomic status respectively.

Table 39: Frequency (f) and percentage (%) of the children in different socioeconomic statuses

		Socioeconomic status		
		Lower	Middle	Upper
Boys (n=445)	f	153	120	172
	%	34.38	26.96	38.65
Girls (n=460)	f	138	133	189
	%	30	28.91	41.08

5.6.1.1. Results:

The performance scores of different cognitive parameters of both boys and girls have been presented in Table 40. From the results it was revealed that mean scores of cognitive parameters such as colour trail test (CTT), colour cancellation test (CCT) were found to be decreased from lower to higher socioeconomic status, indicating improvement of cognitive ability with betterment of socioeconomic condition of the children as those were time parameters. Other cognitive parameters also showed improvement in cognitive functioning, as the sores of different tests, viz., Picture completion test (PCT) ,FAS phonemic fluency test (FAS), Verbal memory test (REC) and verbal learning test (LOT) were gradually increased from different socioeconomic gradients..

Table 40: Mean ± SD and ANOVA of different cognitive parameters among different socioeconomic groups of primary school children

Cognitive parameter	Lower economic group		Middle economic group		Upper economic group		F -ratio	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Colour trail test (CTT)	160.58 ±66.0	151.26 ±67.61	96.60 ±30.54 ***	89.08 ±24.48 ***	82.50 ±28.41 *** ###	82.21 ±34.16 *** #	129.67 $$$	105.52 $$$
Colour cancellation test (CCT)	166.23 ±65.88	145.27 ±54.34	99.55 ±32.47 ***	93.29 ±24.85 ***	91.32 ±39.62 ***	85.64 ±37.84 *** #	107.29 $$$	94.40 $$$
Picture completion test (PCT)	2.85 ±1.03	2.91 ±1.08	3.90 ±0.89 ***	3.82 ±1.05 ***	3.95 ±0.80 ***	3.95 ±0.85 ***	67.81 $$$	49.25 $$$
Fas phonemic fluency test (FAS)	2.27 ±1.57	1.96 ±1.51	3.83 ±1.89 ***	3.98 ±1.81 ***	4.54 ±2.50 *** ##	4.42 ±2.61 *** #	48.74 $$$	57.63 $$$
Recognition (REC)	5.45 ±1.77	5.48 ±1.74	8.28 ±3.20 ***	8.99 ±3.35 ***	9.04 ±3.12 *** #	9.01 ±3.03 ***	70.58 $$$	74.46 $$$
Learning of trials (LOT)	6.67 ±2.70	6.57 ±2.90	7.21 ±2.35	8.02 ±3.75 ***	10.93±3.89 *** ###	9.98 ±3.71 *** ###	86.14 $$$	38.54 $$$

w.r.t. Lower economic gr : * p<0.05, ** p<0.01, *** p<0.001, , w.r.t. Middle Economic gr: # p<0.05, ## p<0.01, ### p<0.001 F ratio: $$ $ p<0.001

The ANOVA was computed to find out significant variation between different socioeconomic gradients. The results of ANOVA showed that there were significant variations ($p<0.001$) within the different socioeconomic gradients. Post hoc analysis demonstrated that the boys and girls of primary school belonging to lower socioeconomic status had lesser performance scores compared to that of middle and upper socioeconomic status. On the other hand, the participant belonging to upper socioeconomic status showed significantly ($p<0.001$) greater scores than rest of the socioeconomic group.

The results of correlation coefficients of the scores of different cognitive parameters with composite score of socioeconomic status of the children have been shown in Table 41. From the results it was noted that all the score of cognitive parameters were significantly ($p<0.001$) and positively correlated with socioeconomic status except CTT and CCT. A significant ($p<0.001$) negative correlation was observed between socioeconomic status and CTT and CCT.

Table 41: Correlation coefficient of cognitive skill with socioeconomic composite score

Cognitive parameters	Boys	girls
Colour trail test (CTT)	-0.610*	-0.572*
Colour cancellation test (CCT)	-0.553*	-0.565*
Picture complitation test (PCT)	0.489*	0.446*
Fas phonemic fluency test (FAS)	0.518***	0.473***
Recognition (REC)	0.532***	0.504***
Learning of trials (LOT)	0.440***	0.370***

***p<0.001

Correlation coefficients of the score of different cognitive parameters with different socioeconomic factors and family sizes have been shown in Table 42. From the results it was noted that all the cognitive parameters, were significantly ($p<0.001$) and positively correlated with different socioeconomic factors, except with family size, CTT and CCT.

The CTT and CCT had significant negative correlation (p<0.001) with different socioeconomic factors except with family size. It was noted that the family size had significant positive correlation (p<0.001) with the scores of CTT and CCT where as it was significantly (p<0.001) and negatively correlated with rest of the cognitive parameters.

Table 42: correlation coefficient of cognitive parameter with different socioeconomic factors

Socio-economic factors	Colour trail test (CTT)	Colour cancellation test (CCT)	Picture complitation test (PCT)	Fas phonemic fluency test (FAS)	Recognition (REC)	Learning of trials (LOT)
Parental yrs of education	-0.429***	-0.386***	0.282***	0.262***	0.295***	0.317***
Parental occupation	-0.366***	-0.353***	0.278***	0.285***	0.303***	0.276***
Parental income	-0.360***	-0.353***	0.279***	0.277***	0.299***	0.284***
Family size	0.368***	0.356***	-0.226***	-0.223***	-0.238***	-0.306***

***p<0.001

Linear regression analysis of socioeconomic status with the score of cognitive skills of both boys and girls has been presented in Tables 43 and 44 respectively. It was observed from the results of regression analysis that socioeconomic status (SES) had significant (p<0.001) association with the score of different cognitive parameters. The result of multiple regression analysis demonstrated that after controlling for the effect of the age, height, weight, and BMI, it was found that SES had significant impact on the cognitive parameters. Therefore, socioeconomic status might be one of the important confounding factors for the variability of the cognitive performances.

Table 43: Regression analysis of socioeconomic status as independent variable and cognitive parameters are dependent variables (Boys)

Variables	Unadjusted						Adjusted#			
	B	**SeB**	**β**	**R^2 change**	**F change**	**T**	**B**	**SeB**	**β**	**T**
CTT	-4.68	0.293	-0.607	-0.368	256.44	-16.01 ***	**-4.175**	**0.361**	**-0.541**	**-11.55 *****
CCT	-4.38	0.320	-0.547	0.299	187.85	-13.70 ***	**-3.54**	**0.403**	**-0.442**	**-8.79 *****
PCT	0.069	0.006	0.48	0.235	135.37	11.63 ***	**0.055**	**0.007**	**0.386**	**7.42 *****
FAS	0.168	0.013	0.520	0.271	163.47	12.78 ***	**0.113**	**0.015**	**0.352**	**7.69 *****
REC	0.23	0.01	0.52	0.28	171.09	13.08 ***	**0.119**	**0.017**	**0.272**	**7.16 *****
LOT	0.225	0.022	0.44	0.196	107.08	10.34 ***	**0.189**	**0.02**	**0.37**	**7.02 *****

* **p<0.001 # after adjusting age , height, weight, and BMI

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test, FAS - Fas phonemic fluency test, REC- recognition, LOT-learning of trials]

Table 44: Regression analysis of socioeconomic status as independent variable and cognitive parameters are dependent variables (Girls)

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
CTT	-4.17	0.279	-0.573	0.328	223.79	-14.96 ***	**-3.29**	**0.343**	**-0.453**	**-9.61 *****
CCT	-3.66	0.250	-0.566	0.320	215.47	-14.67 ***	**-2.83**	**0.308**	**-0.437**	**-9.20 *****
PCT	0.066	0.007	0.446	0.199	113.77	10.66 ***	**0.056**	**0.007**	**0.378**	**7.42 *****
FAS	0.150	0.013	0.473	0.224	132.31	11.50 ***	**0.115**	**0.015**	**0.363**	**7.61 *****
REC	0.220	0.018	0.504	0.254	156.24	12.50 ***	**0.149**	**0.016**	**0.341**	**9.17 *****
LOT	0.189	0.022	0.370	0.137	72.71	8.52 ***	**0.176**	**0.28**	**0.345**	**6.21 *****

***p<0.001 # after adjusting age, height , weight, BMI.

[CTT- colour trail test, CCT- colour cancellation test, PCT- picture completion test, FAS - Fas phonemic fluency test, REC- recognition, LOT-learning of trials]

5.6.1.2. Growth curve of cognitive skills in variation to Socioeconomic status of children.

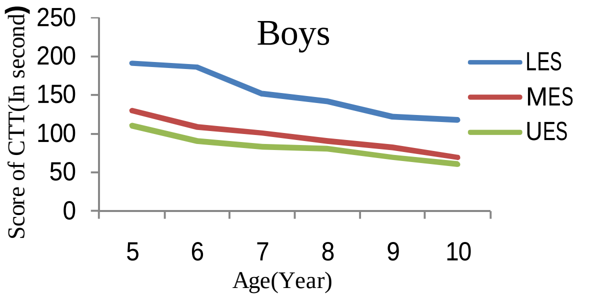

Fig-68: Growth pattern of colour trail test of boys in variation to socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

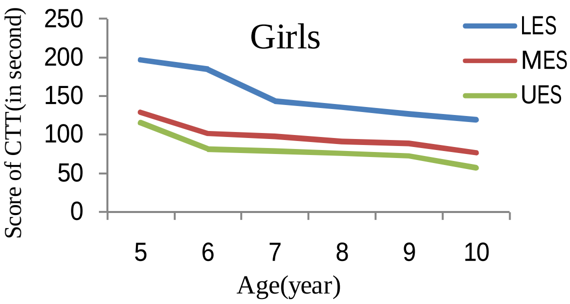

Fig-69:Growth pattern of Colour cancellation test of girls in variation to Socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

The growth pattern of different cognitive skills of boys and girls in variation to Socioeconomic status has been presented in Figs. 68 to 79. From the Figs. 68 to 71 , It has been noted that the pattern of growth of attention of boys and girls varies in variation to Socioeconomic Status. The Figs indicated that the score of attention (CTT,CCT) of boys and girls become maximum in the children of lower socioeconomic status and gradually decreases as Socioeconomic status changes from lower socioeconomic status to upper socioeconomic status. This type of pattern of growth indicates better performances of the boys and girls belonged to upper socioeconomic status.

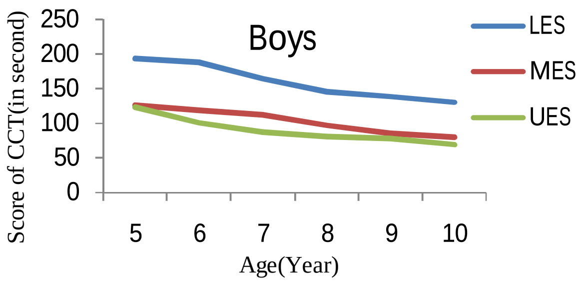

Fig-70: Growth pattern of Colour cancellation test of boys in variation to socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

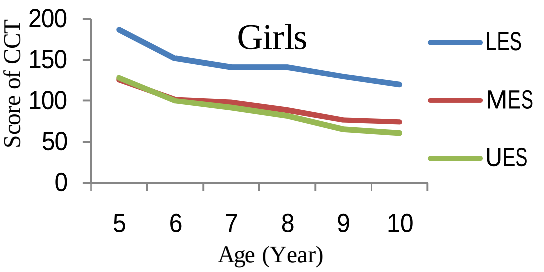

Fig-71: Growth pattern of colour cancellation test of girls in variation to socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

The growth curve of the picture cancellation test (PCT) of boys and girls showed that the scores of the test were gradually increased with the variation of socioeconomic gradient (Fig. 72 and 73) representing better performances of PCT of the boys and girls in the children of upper socioeconomic status .

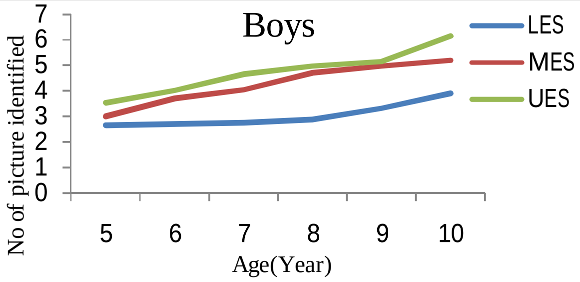

Fig-72: Growth pattern of Picture completion test of boys in variation to socioecomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

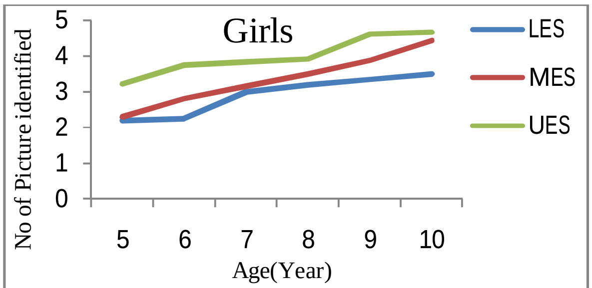

Fig-73: Growth pattern of picture completion test of girls in variation to socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

The growth curve of the phonemic fluency (FAS) of boys and girls showed that the scores of the test were gradually increased with the variation of socioeconomic gradient (Fig. 74 and 75) representing better performances of FAS of the boys and girls in the children of upper socioeconomic status .

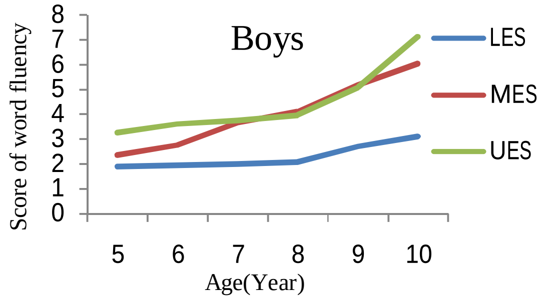

Fig-74: Growth pattern of phonemic fluency in variation to socioecomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

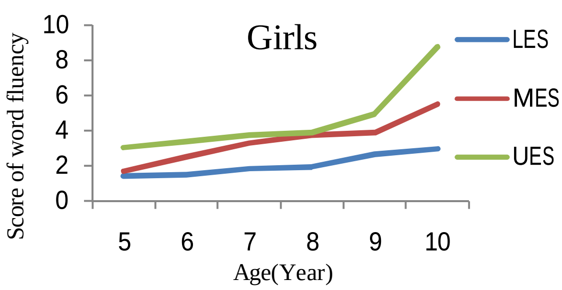

Fig-75: Growth pattern of phonemic fluency of girls of different socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

From the Figs. 76 and 79 it was noted that the growth curves of the scores recognition (REC) and of learning of trials (LOT) was found to be higher score in the boys and girls belonged to upper socioeconomic status . The pattern of the growth curve indicated that Socioeconomic status related betterment in the ability of verbal learning and verbal recognition in boys and girls.

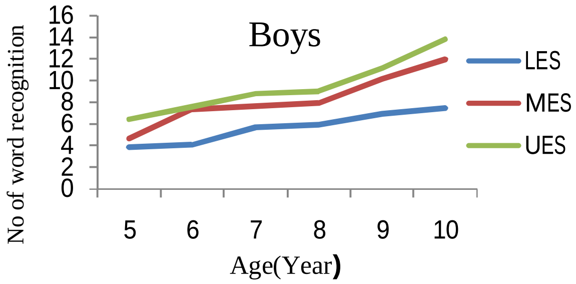

Fig-76: Growth pattern of word recognition of boys in variation to socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

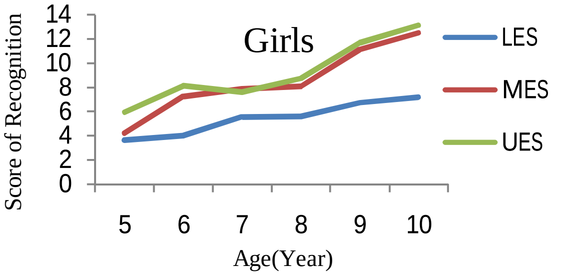

Fig-77: Growth pattern of recognition of girls in variation to Socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

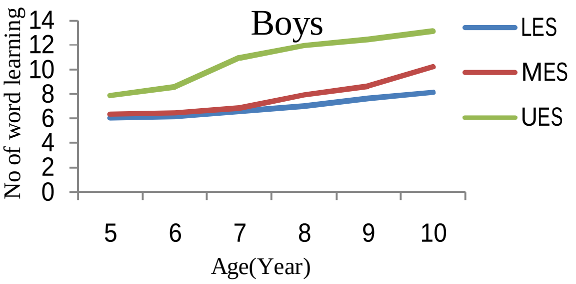

Fig-78: Growth pattern of learning of boys in variation to socioeconomic status

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

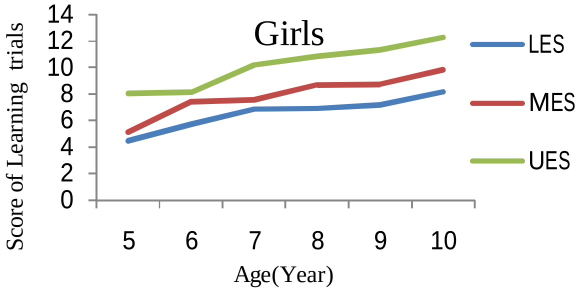

Fig-79: Growth pattern of learning og girls in variation to Socioeconomic Status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

5.6.1.3 Discussion

5.6.1.3.1. Effect of socioeconomic status on verbal learning and memory

The result of the present study showed (Table 40) that socio-economic status had an effect on learning and memory of the children. The level of SES showed various degrees cognitive development in primary school children (Table 40). Similar findings were also observed by the other investigators (Duncan et al. 1994., Noble et al., 2007., Adlar et al. 2008). Other studies (Brooks et al. 1997., Mcloid, 1998., Guo et al. 2000 ., Goodman et al. 2003., Sirin, 2005) also established that SES of the children affect the cognitive development which had a significant and positive correlation with intelligence and academic achievement from the childhood to adolescence.

Previous studies pointed out some factors that might have indirect effects on learning process of the children. A higher rate of depression, anxiety, and attention problem were observed among the children with lower SES back ground in comparison to that of higher SES back ground (Goodman et al. 2003., Sirin, 2005., Shanahan et al., 2008., Tracy et al. 2008, Merikangas et al. 2010). Several studies found that SES had extreme affect on various newer cognitive system such as language processing and moderate affect on the working memory and cognitive control (Farah et al. 2006., Noble et al. 2007., Kishiyama et al. 2009). Language problem were also noted as an effect of SES (Whitehurst et al. 1997). It was postulated that SES was positively correlated with the functions of inferior frontal gyrus which was activated during language task (Daniel et al. 2008). The study also showed decreased language function of the left hemisphere in the children with low SES. The SES related difference in executive function of working memory has been noted in children and adult. The SES influenced verbal and spatial working memory in the children and adolescents and working memory in late childhood (Noble et al.

2005 & 2007., Farah et al. 2006). Efforts have been made by different investigators to explain the influence of socioeconomic status of individual on the learning process in terms of neurological functions. The poverty affects the five consecutive cognitive functions such as language, executive function, memory, spatial cognition and visual function (Noble et al. 2005). The left perisylvian region and other region of the temporal cortex might be involved in semantic, phonological and grammatical processing of language (Binder et al. 1997.,Catani et al.2005).The medial temporal area including hippocampus was found to be significantly important for the consolidation of memory and retrieval (Squire et al. 2011).

The frontal cortex was highly susceptible to the negative effect of SES disparity (Kishiyama et al.2009). Further studies revealed that parental SES was associated with delayed maturation of prefrontal cortex, impulsive decision making, delayed attention (Gianaros et al. 2010) and deficit of variety of cognitive ability, such as reading, learning, and language, that persisted into adulthood (Kishiyama et al. 2009.,Gianaros et al. 2010). In rich SES condition, the enriching activities such as learning and cognitive task that caused the growth of a new neurones in hippocampus, on the contrary, the stressful environment caused the opposite effct on hippocampus, i.e., decrease the neurogenesis on that region (Sapolsky 2003., Hanson et al. 2011., Evan et al. 2009., Farah et al. 2006).

5.6.1.3.2 Effect of socioeconomic status on executive function of the children

The result of the present study showed (Table 38) that executive function such as, visuospatial function (PCT) and phonemic verbal fluency (FAS) of the children had strong and positive correlation ($p<0.001$) with socioeconomic status. The attention parameters (CTT, & CCT) were negatively ($p<0.001$) correlated with socioeconomic status. The lower score in CCT and CTT indicated improvement in performance. Thus it pointed out that the attention, visuospatial function and phonemic verbal fluency might be increased with the improvement of SES. Our results were in conformity with the result of Farah et al. (2006)., Noble et al. (2007) suggested that attention and visuospatial function of the children was positively correlated with socioeconomic status. It was found from the results (Table 40) that performances of the tests of attention and visuospatial function of the children gradually increased with the improvement of parental socioeconomic gradient.

Rosa et al. (2014) investigated on the effect of socioeconomic status and stress reactivity impact on neuro cognitive performances of children and they suggested that children with a younger age and low SES exhibited lower cognitive performance compared with older children with a high SES when the children were 6 years old. At 16 years of age, however, the result was the opposite. Children with low SES exhibited better selective attention than children with high SES. These results, however, might have been influenced by the fact that each age group had a few participants and the fact that children with low SES were more likely to leave school or refuse to participate in research because of their cognitive deficits.

Amza (2013) and Noble et al. (2007) investigated the effect of socioeconomic status on brain development demonstrated that SES on five basic cognitive systems: language, executive function, memory, spatial cognition, and visual. Middle-class children performed better than low-income peers on language, memory, and executive function such as fluency test and visuospatial function.

Several researches focused specifically on the neurocognitive effects of poverty helps to further clarify possible changes in the brain, with different studies providing evidence of SES influences on executive function (Hanson et al. 2012). It was established that frontal lobe had been implicated in executive functions such as planning, impulse control, and control of attention (Stuss 2011). It was reported that this brain region also had a protracted course of post-natal development and might be particularly vulnerable to the effects of early stress and experience (Toga et al. 2006). Additionally, alterations in the frontal lobe might be particularly important for the elevated rates of learning, behavioural, and health problems of children from low SES backgrounds was suggested. The results of longitudinal research suggested that increased duration of a child’s exposure to poverty was related to greater deficits in executive function and working memory in adulthood (Evans et al. 2009). Further work examining SES, behavioural performance, and the neural correlates of selective attention had found differences in evoked brain activity.

Electroencephalographic study of D’Angiulli et al. (2012) showed that children with higher SES had greater differentiation of event-related potentials between relevant and irrelevant stimuli in a task of detecting sequences of tones compared with children with low SES who had hypo activity in medial frontal regions. Other studies on EEG showed that young children from lower-SES backgrounds display lower electrical activity when deploying different aspects of selective attention, a cognitive process dependent on the frontal lobe (D'Anguilli et al. 2008 .,Stevens et al., 2009).

Low SES environments influence the rate of human infant brain development. Infants, toddlers and preschoolers from lower income families began their lives with similar gray matter brain volumes but had lower total gray matter compared with those from middle and high-income households by toddlerhood (Hansons et al. 2013). A large body of research has found the frontal lobe is centrally involved with executive functions such as planning, impulse control, and control of attention (Stuss 2011). Previous research established that the parietal lobe was important for sensory integration and aspects of visual attention as well as responsible for visuospatial functioning (Blakemore 2005). Development of the parietal lobe might be particularly important for connectivity between brain regions and it was also established that the volume of parietal lobe was decreased in the children of the family of lower socioeconomic status and therefore visuospatial functioning activity also was decreased in the children of the family of the lower socioeconomic status (Hansons et al. 2013). In regards to neurobiological mechanisms, the differences in volume might be due to neuronal remodelling, rather than birth of new neurons (or neurogenesis) (May, 2011., Zatorre 2012). Volumetric differences associated with environmental experience were likely related to an increase in synapses along with increases in supportive tissue, including both capillaries and glia (Anderson 2011).

It was found from (Table 42) results that different socioeconomic factors such as parental years of education, occupation, income and finally numbers of family members were directly correlated with different cognitive parameters. Desforges and Abouchaar, (2003) suggested that parental involvement was influential element that provoked the positive development of learning and educational output of the children. Desforges and Abouchaar, (2003) reported that parental involvement takes many forms including good parenting in the home, including the provision of a secure and stable environment, intellectual stimulation. Low Socioeconomic families were least likely to be involved in their students' education (Turney and Kao, 2009., Ratcliff and Hunt, 2009., Van Velsor and Orozco, 2007). Low Socioeconomic families were often working all of the time to take care of their families, and they have no time to participate in their child's education at home (Ratcliff and Hunt, 2009). Based on a study involving low socioeconomic mothers, mothers want to be involved in their child's education, but the other household problems was that they were less comfortable around teachers, and so they do not get involved (Machen, Wilson &Notar, 2005).

Parental education level was also important factors for children educational and behavioural outcomes. Parent's educational level and the parental involvement strategies at home revealed that parent with higher educational level were more involved with their children's studies compared to parents of lower socioeconomic status (Matalka 2014). The parents with lower socioeconomic status, their educational level was very poor, so, their involvement in home at their child's study was very less. Parents with high educational level were more involved in discussion on school activities taking by the children at school so that to understand the activities and other things that their children do in school, identifying academic problems at school that being faced by children so that to discuss it with the children, the school teachers and principle in order to find best solutions for these problems (Matalka 2014). They were also more likely to be involved in assisting their children with their home work, and in identifying homework in order to make difficulties easier to them and also to save the time that the children spend in trying to solve and complete their homework. Moreover, they are more likely to be involved in identifying learning patterns of their children and in determining time limits for their children everyday study activities (Matalka 2014).

5.6.2. Effect of socioeconomic status on motor ability of children

5.5.2.1. Results:

The performance scores in different motor ability tests of boys and girls across different socioeconomic groups have been presented in Table 45. It was noted that the scores of reaction time were decreased from lower SES to higher SES indicating better reaction time of the primary school children with the increase of SES. The scores of the peg board test with dominant and both hands of boys and girls were gradually increased from lower socioeconomic status to upper socioeconomic status. ANOVA was applied for the scores of motor skill parameters between different socioeconomic groups. The results of ANOVA showed significant (p<0.001) variation within different socioeconomic gradients.

Table-45: Scores (Mean ±SD) of different motor parameters of boys and girls of primary School

Motor parameters	Lower economic group		Middle economic group		Upper economic group		F ratio	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Reaction Time (Sec)	0.315 ±0.060	0.299 ±0.054	0.232*** ±0.035	0.208*** ±0.028	0.197***### ±0.044	0.190***### ±0.045	240.02$$$	263.43 $$$
Peg board score of dominant hand	6.75 ±1.75	7.29 ±2.04	9.32 ±2.10 ***	9.16 ±2.08 ***	11.46 ±2.81 *** ###	10.61 ±2.48 *** ###	164.18 $$$	85.95 $$$
Peg board score of nondominant hand	6.07 ±1.66	6.81 ±1.99	8.36 ±1.63 ***	8.54 ±2.02 ***	10.16 ±2.31 *** ###	9.73 ±2.39 *** ###	175.90 $$$	71.34 $$$
Peg board score of both hand	4.63 ±2.42	5.28 ±2.42	7.10 ±2.80 ***	7.58 ±2.63 ***	9.43 ±3.19 *** ###	8.35 ±2.99 *** #	112.39 $$$	51.83 $$$

w.r.t. Lower economic gr: * p<0.05, ** p<0.01, *** p<0.001 ; F ratio: $$$ p<0.001 ;
w.r.t. Middle Economic gr: # p<0.05, ## p<0.01, ### p<0.001

Post hoc analysis demonstrated that scores of reaction time of the children belonging to lower socioeconomic group were significantly (p<0.001) greater than that of the children belonging to middle and upper socioeconomic groups.The scores of peg board test of children belonging to upper socioeconomic status were significantly ($p<0.05$ or less) greater than that of the children belonging to middle and lower socioeconomic groups.

The results of correlation coefficients of composite socioeconomic scores with different motor ability parameters have been shown in Table 46. From the results it was noted that all the score of motor parameters were significantly ($p<0.001$) correlated with socioeconomic scores. The reaction time showed negative correlation and the peg board test scores had positive correlation with socioeconomic status.

Table 46: Correlation coefficients of motor ability parameters with composite socioeconomic scores

Motor parameters	Boys	Girls
RT	-0.718***	-0.678***
DH	0.660***	0.539***
NDH	0.654***	0.501***
BOTH HAND	0.591***	0.456***

***p<0.001, RT- Reaction Time, DH- Peg board test by dominant hand, NDH- Pegboard test by non dominant hand

The correlation coefficients of the scores of different motor parameters with different socioeconomic factors and family size have been shown in Table 47. From the result it was noted that all the motors parameters were significantly ($p<0.001$) correlated with different socioeconomic factors.

Table 47: Correlation coefficient of cognitive parameter with different Socioeconomic factors.

Socioeconomic factors	RT	DH	NDH	BOTH HAND
Parental yrs of education	-0.490***	0.431***	0.425***	0.359***
Parental occupation	-0.461***	0.445***	0.415***	0.349***
Parental income	-0.462***	0.432***	0.410***	0.361***
Family size	0.473***	-0.363***	-0.382***	-0.357***

***p<0.001 ,RT Reaction Time, DH- Peg board test by dominant hand, NDH- Pegboard test by non dominant hand

The reaction time had significant negative (p<0.001) correlation with the level of parental education, occupation and income but family size showed positive correlation. The peg board scores of dominant hand, nondominant hand, both hand were positively correlated with all socioeconomic factors excepting the family size.

Linear regression analysis of socioeconomic status with the score of motor ability scores of both boys and girls have been shown in Tables 48 and 49 respectively. It was observed from the results of regression analysis that socioeconomic status had significantly (p<0.001) associated with the scores of different motor ability scores. Result of multiple regression analysis indicated that after adjusting for the effect of the age, height weight, and BMI, it was found that SES had significant impact on the motor parameters. Therefore, socioeconomic status might be an important influencing factor for the variability of the motor performances.

Table 48: Regression analysis of socioeconomic status as independent variable and motor parameters as dependent variables (Boys).

Variables	**Unadjusted**						**Adjusted#**			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
RT	-0.007	0.000	-0.719	0.516	469.6	-21.67 ***	**-0.006**	**0.000**	**-0.615**	**-16.86 *** **
DH	0.95	0.076	0.514	0.264	157.83	12.56 ***	**0.65**	**0.08**	**0.35**	**7.57 *** **
NDH	0.235	0.013	0.655	0.429	330.05	18.16 ***	**0.187**	**0.014**	**0.523**	**13.002*** **
BOTH HAND	0.283	0.018	0.590	0.349	235.44	15.34 ***	**0.224**	**0.021**	**0.467**	**10.40 *** **

***p<0.001 # after adjusting age height, weight, BMI [RT- Reaction Time, DH- Dominant Hand, NDH-Non Dominant Hand, BMI-Body mass index]

Table 49: Regression of analysis of socioeconomic status as independent variable and motor parameters as dependent variables (Girls)

Variables	Unadjusted						Adjusted#			
	B	SeB	β	R^2 change	F change	T	B	SeB	β	T
RT	0.006	0.000	-0.698	0.487	435.45	-20.86 ***	**-0.005**	**0.000**	**-0.602**	**-14.64 *** **
DH	0.191	0.014	0.540	0.291	188.26	13.72 ***	**0.164**	**0.014**	**0.462**	**11.54 *** **
NDH	0.168	0.014	0.501	0.251	153.85	12.40 ***	**0.134**	**0.013**	**0.4**	**10.08 *** **
BOTH HAND	0.186	0.017	0.456	0.208	120.53	10.97 ***	**0.159**	**0.019**	**0.390**	**8.17 *** **

***p<0.001 # after adjusting age,height,weight,BMI[RT- Reaction Time, DH- Dominant Hand, NDH-Non Dominant Hand ,BMI- Body mass index]

5.6.2.2. Growth curve of Motor ability in variation to socioeconomic status of the children.

The pattern of growth curve of reaction time of boys and girls in variation to Socioeconomic Status has been presented in Figs. 80 and 81 Which represent that the score of reaction time gradually decreases according to advancement of socioeconomic gradient. This type of pattern of growth pattern of performances of reaction time indicated that better performances as the socioeconomic status increases.

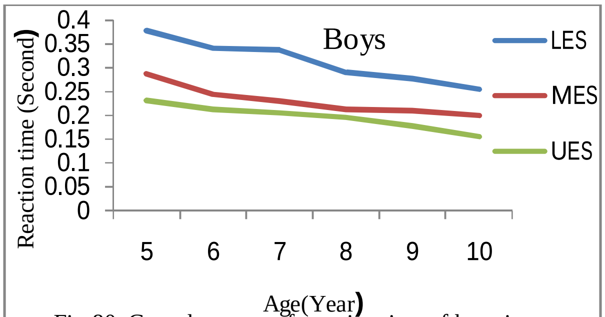

Fig-80: Growth pattern of reaction time of boys in variation to socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

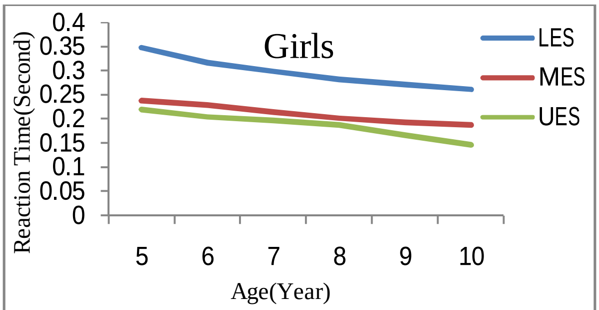

Fig-81-: Growth pattern of reaction time of girls in variation to socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

From the Figs 82 and 83, it was noted that growth curve of pegboard test by dominant hand of boys and girls gradually increased form lower Socioeconomic Status to upper Socioeconomic status. This type of growth pattern of boys and girls indicated that increment of ability of peg placing activity due to advancement of Socioeconomic Status.

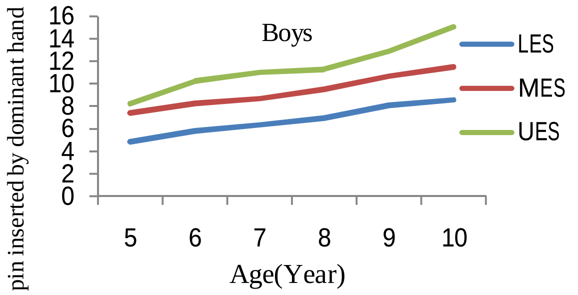

Fig-82: Growth pattern of peg board test by dominant hand in variation to socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

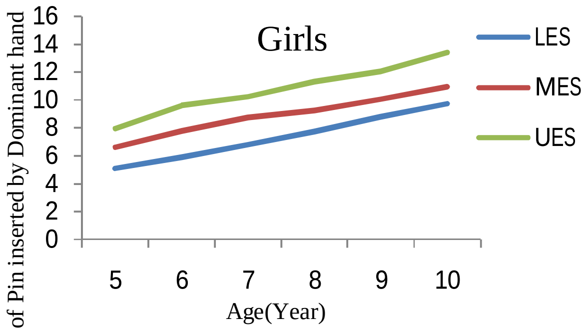

Fig-83: Growth Pattern of peg board test by dominant hand of girls in variation to Socioeconomic Status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

The growth pattern of the activity of non dominant hand and both hand has been presented in figures 84 to 87 .The curved revealed that the score of pegboard test by nondominant hand and both hand gradually become maximum from the children belonged to lower Socioeconomic status to the children of upper Socioeconomic Status. This type of pattern of the growth curve of the children indicated that Socioeconomic Status related better performances of non dominant hand and both hand of boys and girls.

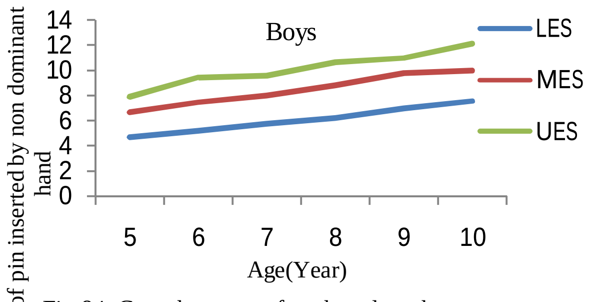

Fig-84: Growth pattern of pegboard test by non dominant hand in variation to socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

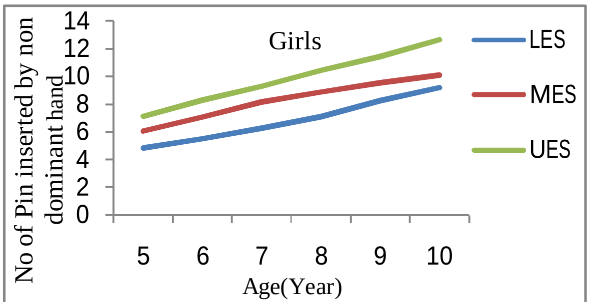

Fig-85: Growth Pattern of pegboard test by non dominant hand in variation to Socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

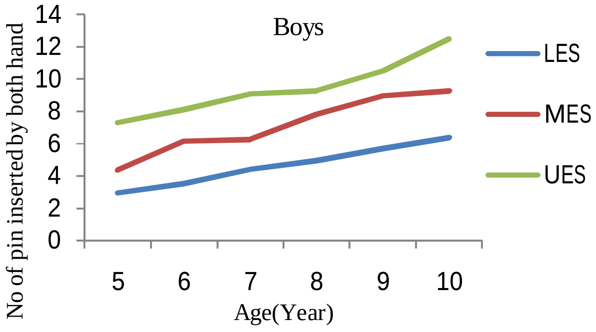

Fig-86: Growth pattern of pegboard test by both hand in variation to socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

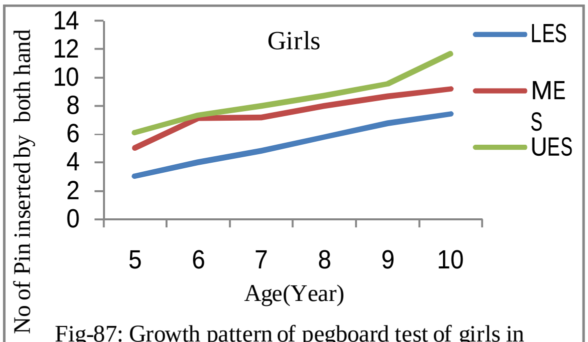

Fig-87: Growth pattern of pegboard test of girls in variation to Socioeconomic status.

LES-Lower economic status, MES- Middle economic status, UES- Upper economic status

5.6.2.3. Discussion:

Lower reaction time represents better motor skill of a person. The results of the present study showed that the reaction time of school children was the highest in children having lowest socioeconomic status and it was found to be lower as the SES became high. Further, significant negative correlation was found between SES and reaction time. That means that the motor skill in terms of reaction time gradually increased with the increase in the level of socioeconomic status. Henneberg et al. (2001) observed slower neuromuscular reaction (reaction time was measured by means of a falling ruler test) in children with low SES and concluded that the difference in neuromuscular control of strength may be responsible for the findings.

The results of pegboard test represented the finger dexterity and fine movements of arms of the children. It was observed that the finger dexterity and fine movements of arms of boys and girls of the primary school children had a definite variation with the variation of socioeconomic variation of their family. This motor ability was found to be augmented as a function of their socioeconomic score.

Thus the socioeconomic factors were major determining factors for the development of motor skill of the children. It was noted from the result (Table 45) that performances of fine motor skill of the children of lower socioeconomic background children was poorer compared to children of middle and upper socioeconomic background. The result of this study was similar to the studies of other investigators (Lejgaraga et al. 2002 ., Freitas et al. 2013. Leggaraga et al .(2002) reported that higher social class and educational level of the mother was related to the better psychomotor performance in children over 1 year of age. Kambas et al. (2010) also demonstrated that especially the poor urban children living in apartment blocks may suffer from the lack of enough space that prevents them from developing their gross motor skills too.

In the present study it was revealed (Table 47) that parental years of education, occupation and income of the family had direct correlation with fine motor skill of the primary school children. The level of parental education, occupation and income of the family constitutes the home environment that played a crucial role for the development of motor skill of children. Galobardes et al. (2006) stated that during infancy and early childhood determination of motor skill was the best indicators for parental education / occupation and household income /conditions. The contribution of SES for motor development of the child has been reported world-wide. In general, the literature indicated that families with a low SES have children that perform below the norm for developing children (Kanbas and venetsanou, 2010; Chowdhury et al. 2010). These observations applied to the relationship between motor development and parental social class/ education (Lejgaraga et al. 2002; Barros et al. 2010; Janssen et al. 2011) and family income (Engle et al. 2008).

So, parents of higher socioeconomic status could afford sufficient nutrient and possesses different household features there by favouring the acquisition of a higher number of toys and larger space that favours the development of fine motor skill of the children. Freitas et al. (2013) demonstrated that physical space is necessary for infants to move freely, and toys afford possibilities for enhancing fine- and gross-motor skills. To et al. (2001) suggested that low maternal education, maternal depression, parenting practices and low income adequacy begin to play a role in child's development at 2 years of age.

The socioeconomic variations of motor abilities might be mediated through alteration of neurophysiologic functioning of the children. Noble et al. (2005) reported that all brain systems are to some degree modifiable by experience, and the specific environmental factors associated with SES may impact cognitive functions that rely on certain brain systems for reasons other than the systems' developmental time table.

Norms for parameters of cognitive skills and motor abilities

Chapter 6

6.0 Norms for cognitive skills and motor ability parameters for Bengali population:

In this section, grading of norms for different parameters of cognitive skills and motor abilities has been performed.

Norms refers to information regarding the group performance of a particular reference on a particular measure for which a person can be compared to. Norms mean standardized score. Scores on neurophsiological test are most commonly interpreted by reference to norm that represents the test performance on standardization sample.

Basically there are two purposes of norms:

1. Norms indicate the individual’s relative standing in the normative sample and thus permit evaluation of his/her performance in refer to other persons.
2. Norms provide compared measures that permitted a direct comparison of the individual performance on difference test.

In neurophsiological studies normative assessment may be carried out for a variety of reasons, such as:

- Clinical evaluation, to understand the pattern of cognitive strengths as well as any difficulties a person may have, and to aid decision making for use in a medical or rehabilitation environment.
- Scientific investigation, to examine a hypothesis about the structure and function of cognition to be tested, or to provide information that allows experimental testing to be seen in context of a wider cognitive profile.

The norms for cognitive skills and motor abilities were determined and those were divided into five grades such as A, B, C, D, and F,(Johnson and Nelson ,1986) which were designated as ‘Excellent’, ‘Very good’, ‘Good’, ‘Average’ and ‘Poor’ respectively. For representing the norms, the whole age group (5-10 years) of the children was divided into three groups, instead of six age groups, such as 5-6 year,7-8 year and 9-10 year. Such grouping was made as there was no significant difference in performances of different cognitive and motor parameters between two adjacent age groups, e.g., 5 and 6 years, 6 and 7, 6 and 9 years and 9 and 10 years was observed. In each age group the cut off values for different parameters of cognitive skills and motor abilities have been presented in different tables in this section.

The distribution of boys and girls in different grades of the parameters of cognitive skills and motor abilities were analysed. It has been seen from the results that the most of the subjects were belonged to grades B, C, D respectively. Thus such distributions of subject in different grade may be helpful grade for selecting condition for particular activities in different fields such as in school performances and different sports activities among the children.

The norms for the performances of cognitive skill and motor ability were found to vary in different newly formed age groups. In the table the norms for the parameters for cognitive skills and motor abilities at different age groups for boys and girls of Bengali population have been outlined. In case of the age group 5-6 year the higher and lower cut off values for colour trail test (CTT) and colour cancellation test (CCT) for boys and girls has been presented (Table 50).

As those parameters represented the score in time (sec) and lower time indicated the better performance, the scores were increased from category A to D. Thus the lower scores were belonging to Category A. It was noted that the frequencies of boys and girls were the maximum in B and C, i.e., very good' and 'Good' categories for the above two tests. Similarly in other age groups, viz., 7-8 years, and 9-10 years, the same trends of results were observed (Table 51 and Table 52). The highest frequency of the subjects was noted in group C expecting CTT in the age group of 9-10 year for boys.

Table- 50: Norms for Colour trail test (CTT) and Colour cancellation test (CCT) of boys and girls at age group 5- 6 yrs

Grade	CTT				CCT			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	<45	3	<43	2	<40	1	<50	4
B	46-105	51	44-99	53	41-104	53	51-100	47
C	106-164	50	100-155	64	105-167	57	101-150	52
D	165-229	25	156-211	26	168-231	18	151-200	31
F	>230	14	>212	10	>232	14	>201	15

Table- 51: Norms for Colour trail test (CTT) and colour cancellation test (CCT) of boys and girls at age group 7-8 yrs

Grade	CTT				CCT			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	<40	1	<31	1	<36	4	<44	3
B	41-82	53	31-78	48	37-91	43	45-85	48
C	83-124	70	79-125	74	92-145	75	86-127	66
D	125-167	19	126-172	13	146-199	23	128-168	22
F	>168	17	>173	16	>200	17	>169	13

Table- 52: Norms for Colour trail test (CTT) and colour cancellation test (CCT) of boys and girls at age group 9- 10 yrs

Grade	CTT				CCT			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	<24	2	<22	1	<24	3	<19	2
B	23-71	60	22-62	48	25-74	54	20-65	35
C	72-121	47	63-105	77	75-124	55	66-109	92
D	122-170	14	106-145	14	125-174	11	110-153	16
F	>171	17	>146	13	>175	17	>154	12

Table- 53: Norms for Picture completion test (PCT) and phonemic fluency test (FAS) of boys and girls of the age group 5- 6 yrs

Grade	PCT				FAS			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>4	14	>4	9	>5	16	>5	7
B	3.1-4	48	3.1-4	41	3-5	14	3-5	32
C	2.1-3	48	2.1-3	59	2-3	81	2-3	86
D	1-2	27	1-2	39	1-2	18	1-2	20
F	<1	6	<1	7	<1	14	<1	10

Table- 54: Norms for Picture completion test (PCT) and phonemic fluency test (FAS) of boys and girls of the age group 7-8 yrs

Grade	PCT				FAS			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>5	34	>5	27	>8	8	>9	7
B	4-4.9	63	4-4.9	63	6-7	42	6-8	52
C	3-3.9	46	3-3.9	44	4-5	67	4-5	68
D	2-2.9	17	2-2.9	18	2-3	36	2-3	19
F	<2	2	<2	2	<1	5	<1	6

Table- 55: Norms for Picture completion test (PCT) and phonemic fluency test (FAS) of boys and girls of the age group 9-10 yrs

Grade	PCT				FAS			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>5	4	>5	4	>10	5	>10	12
B	4-4.9	52	4-4.9	70	7-9	58	7-9	28
C	3-3.9	47	3-3.9	71	5-6	35	5-6	72
D	2-2.9	33	2-2.9	7	2-4	37	2-4	36
F	<2	4	<2	7	<1	5	<1	3

The norms for picture completion test and phonemic fluency test of Bengali children of 5-6 yrs, 7-8 yrs and 9-10 yrs have been presented in Tables 53, 54 and 55 respectively. For the age group 5-6 yrs the frequency distribution of PCT and FAS of boys and girls was found to be higher in B and C categories, with the higher frequencies in C group, than that of other categories. For the age group 7-8 years, the occurrence of highest frequency was found in B category for PCT and C category for FAS. For the age group 9-10 yrs, the most of the boys and girls were distributed in B and C categories for PCT and in C and D categories for FAS.

Table- 56: Norms for verbal recognition test (REC) and learning of trials (LOT) of boys and girls of the age group 5- 6 yrs

Grade	REC				LOT			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>11	12	>9	12	>13	5	>12	11
B	8-10	26	7-8	40	9-11	30	9-11	28
C	6-7	53	6-7	44	6-8	66	6-8	55
D	3-5	49	3-5	59	4-5	23	3-5	54
F	<2	2	<2	2	<3	17	<2	7

Table- 57: Norms for verbal recognition test (REC) and learning of trials (LOT) of boys and girls of the age group 7-8 yrs

Grade	REC				LOT			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>12	27	>12	4	>16	6	>15	14
B	10-12	36	9-11	73	12-15	22	12-14	27
C	6-9	29	7-8	37	8-11	75	8-11	50
D	3-5	69	5-6	32	5-7	54	4-7	48
F	<2	1	<4	6	<4	5	<3	13

Table- 58: Norms for verbal recognition test (REC) and learning of trials (LOT) of boys and girls of the age group 9-10 yrs

Grade	REC				LOT			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>16	12	>16	10	>17	8	>17	9
B	13-15	54	13-15	66	12-16	21	13-16	23
C	10-12	38	10-12	40	9-12	54	9-12	59
D	7-9	32	8-9	27	5-8	45	5-8	57
F	<6	4	<7	10	<5	12	<4	5

The cut-off values for different categories for verbal recognition and learning of trials scores of boys and girls of different age group have been presented in Tables 56, 57, and 58. It was noted from the results that for the lowest age group (5-6 yrs) the frequency distribution of the scores of verbal recognition was higher in C and D categories in both boys and girls. It was also noted from the Table 56 that in case of the scores of LOT (learning of trials), majority of the boys and girls were distributed in C category. For the age group 7-8 yrs, the highest frequency of the scores of verbal recognition was in D category for boys and B category in girls. The highest frequency of LOT was noted in category C in both boys and girls. The most of the boys and girls were distributed in B and C categories in the highest age group (9-10yrs). In the case of the score of LOT, majority of boys and girls were distributed in C and D categories.

Table- 59: Norms for Reaction time and peg board score for Dominant hand of boys and girls of the age group 5- 6 yrs

Grade	Reaction Time				Peg board score in Dominant hand			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	<0.167	1	<0.150	3	>12	16	>12	8
B	0.168-0.243	58	0.151-0.219	52	10-11	28	10-11	37
C	0.244-0.319	41	0.220-0.287	54	7-9	44	7-9	80
D	0.320-0.395	34	0.288-0.355	35	5-6	54	5-6	25
F	>0.396	9	>0.356	11	<4	1	<4	5

Table- 60: Norms for Reaction time and peg board score of Dominant hand of boys and girls of the age group 7-8 yrs

Grade	Reaction Time				Peg board score in Dominant Hand			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	<0.148	4	<0.142	13	>15	17	>14	13
B	0.149-0.212	54	0.143-200	30	12-14	52	11-13	30
C	0.213-0.276	67	0.201-0.259	46	9-11	51	8-10	46
D	0.277-0.340	14	0.260-0.317	55	7-8	34	7-8	55
F	>341	23	>0.318	8	<6	8	<6	8

Table- 61: Norms for Reaction time (sec) and peg board score of Dominant hand of boys and girls of the age group 9-10 yrs

Grade	Reaction Time				Peg board score in Dominant Hand			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	<0.135	5	<0.117	3	>17	5	>15	10
B	0.136-0.187	42	0.118-0.173	48	14-16	38	13-14	58
C	0.188-0.238	55	0.174-0.229	58	11-13	57	11-12	50
D	0.239-0.290	24	0.230-0.284	33	8-10	33	9-10	29
F	>291	14	>0.285	13	<7	7	<8	6

The results of norms for the reaction time and pegboard score by dominant hand for the age groups 5-6 yrs, 7-8yrs, 9-10yrs have been presented in Tables 59, 60, and 61 respectively. The result revealed that for the age group 5-6 yrs the dominance of frequency distribution for reaction time score was noted in categories B and C. In case of the age group 7-8yrs the most of the boys were distributed in categories B and C and most of the girls were distributed in categories C and D. In higher age group (9-10yrs) the frequency distribution was higher in B and C categories for both boys and girls.

Table- 62: Norms for peg board score for non dominant hand and both hand of boys and girls of the age group 5- 6 yrs

Grade	Peg board score in Non-Dominant hand				Peg board score in both hand			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>11	9	>10	12	>12	20	>10	12
B	9-10	44	9-10	38	8-11	34	8-9	38
C	7-8	53	7-8	62	5-7	73	5-7	62
D	5-6	34	5-6	40	3-4	-	3-4	40
F	<4	3	<4	3	<2	16	<2	3

Table- 63: Norms for non dominant hand and both hand of peg board test of boys and girls of the age group 7-8 yrs

Grade	Peg board score in Non-Dominant hand				Peg board score in both hand			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>13	7	>13	5	>13	2	>12	18
B	11-12	51	11-12	40	10-12	34	10-11	-
C	8-10	73	8-10	61	7-9	75	7-9	86
D	6-7	24	6-7	31	4-6	48	4-6	46
F	<5	7	<5	15	<3	3	<3	2

Table- 64: Norms for non dominant hand (NDH) and both hand of peg board test of boys and girls of the age group 9-10 yrs

Grade	Peg board score in non-dominant Hand				Peg board score in Both Hand			
	Boys	Frequency	Girls	Frequency	Boys	Frequency	Girls	Frequency
A	>14	8	>15	5	>15	6	>15	6
B	12-13	39	13-14	42	12-14	48	12-14	44
C	9-11	68	10-12	74	8-11	60	8-11	87
D	7-8	20	8-9	27	5-7	26	5-7	16
F	<6	5	<7	5	<4	-	<4	-

The norms for pegboard scores by dominant hand, non dominant hand and both hand of children having age groups of 5-6 yrs , 7-8 yrs and 9-10 yrs have been presented in different tables. The results (Tables 59 & 62) showed that the peg board scores in the age group of 5-6yrs the dominance of frequency distribution was noted in the categories C and D in cases of dominant hand of boys and non-dominant hand and both hands of girls. On the other hand, the categories of B and C had higher frequency distribution in dominant hand of girls and non-dominant hand both hands in boys. For the age group 7-8yrs (Tables 60 and 63) the higher frequency distribution was observed in the categories of B and C for the dominant hand of boys and non-dominant and both hand of girls and it was observed in C and D categories for the dominant hand of girls and both hand for boys and girls in comparison to other categories. In case of the age group 9-10yrs (Tables 61 and 64) the higher frequency distribution of peg board score was evident in B and C categories for all combination of hand in both boys and girls than that of other categories.

The grading of norms for different cognitive and motor ability parameters might be helpful for identifying the position of the primary school children about their cognitive or motor ability strength. It may also a helpful guide for identifying the Bengali children who have cognitive or motor ability strength with clinical or subclinical range.

7.0 Summary of the study

Chapter VII

7.0. Summary

Cognitive skills and motor abilities are important markers of the growth and development of the children. Those abilities are related to the function of the brain. This activities of the brains development occurred from the early infancy to the adulthood. During this period different areas of the brain emerges from immature state to mature state. Total 90% of brain development becomes completed at the age of six.

Cognitive skill development in children involves the progressive building of learning skills such as attention, memory, and thinking. This crucial skills enables children to process sensory information and eventually learn to evaluate analyze, remember and make comparison and understood cause and effect. Although some cognitive skills development is related to child genetic makeup and most of the cognitive skilled are learned. So, the cognitive skills can be improved with suitable environment.

When child learns to pay attention it enables him to concrete on one task or conversation for an extended period of time. Learning to focus attention is an important cognitive skill that child uses virtually all future learning. Memory is an important cognitive skill that equipped a child to retain what he has learned and experienced and therefore build a future base of knowledge. The ability to think includes being able to learn the task and find the solution. This skill helps the children to know whether he's accomplishing what he set out to do or whether he needs to ask for help.

Motor development refers to changes in children's ability to control their body's movement from infant first spontaneous waving and kicking movements to the adaptive control of reaching, locomotion and complex sports skills. The motor behaviour includes all movements of our body including movement of eye and the infant's developing control of head. Gross motor action includes the movement of large limbs or the whole body. Fine motor behaviour includes the use of finger to grasp and manipulate object. Motor behaviour such as, reaching, touching and grasping are the forms of exploratory activity. Motor movements including movement of the eyes, arms, legs and hand provide most of the perceptual information infant receive. As the infant grows, their body fat and muscle mass are redistributed, i.e., increment of muscle strength, neural myelination leads to speed of nerve conduction. Overall mechanism increases motor activities of the children.

Physical growth, cognitive skills and motor abilities are most important for children life. The cognitive skills and motor abilities may vary in different populations due to different factors. The degree by which these factors influence the performances of cognitive and motor abilities should be identified. Although different investigations were made on different populations, no comprehensive study has been conducted on Bengali population. Every population should have their normative data on cognitive and motor parameters of the growing children. However, such normative data is very scanty in Bengali population. That lacuna inspired us to study on cognitive skills and motor abilities on primary school children of Bengali population.

The aim of the present study was aimed to evaluate the cognitive skill and motor ability of primary school children.

The followings are the objectives of present investigation:

1) To evaluate motor ability and cognitive skill of primary school children

2) To evaluate physical growth, nutritional status of the primary school children.

3) To assess age and gender related changes of the motor ability and cognitive skill among the primary school children.

4) To find out the possible association between physical growth and cognitive skill as well as motor ability of primary school children.

5) To find out the possible association of cognitive skill and motor ability of primary school children with nutritional as well as socioeconomic parameters.

6) To find the graded norms for cognitive skill and motor ability parameters of primary school children.

The present study was carried out by primary school going children only. The study was conducted in different district of West Bengal state, India. For the fulfilment of the present study 905 children was employed, out of which 445 were boys and 460 were girls. For the purpose of the present study different cognitive parameters and different motor skill parameters along with socioeconomic status and nutritional status, and physical growth were studied.

The following cognitive and motor abilities tests were performed:

Colour trail test (CTT): It was the study of attention and conceptual tracking.

Colour cancellation test (CCT): It was the study of selective attention.

Fas phonemic fluency test (FAS): It was the study of executive function.

Picture completion test (PCT): It was the study of Visuospatial function.

Rays auditory verbal learning test (RAVLT) : It was the study of verbal learning and memory.

Motor parameters such as Reaction Time (RT) which was the study of reaction time of the children, and Purdue peg board test which was the study of hand eye coordination, were employed. The peg input test was performed on dominant hand (DH), non-dominant hand (NDH) and both hands.

The socioeconomic status of the parents was evaluated by modified Kuppuswami scale. Anthropometric measurements, viz., body weight and height, were taken from the subjects following standard technique and appropriate landmarks. Nutritional status of the participants was evaluated by 24-h recall as well as by the anthropometric methods. BMI was calculated from Height and weight using the following formula: BMI=weight (Kg) / height (meter) ^{2}. The stunted growth of the children was evaluated by the cut-off values of height using WHO guidelines.

The results of variation of cognitive and motor performances on age and sex revealed that there was a significant variation in performances of cognitive skill and motor ability of boys and girls from 5yrs to 10 yrs of age. The scores of Colour trail test (CTT) and Colour cancellation test (CCT) were found to be decreased with the advancement of age indicating better attention and conceptual tracking as well as selective attention of the children, as those were time related parameters. On the other hand, the scores of Fas phonemic fluency test (FAS), picture completion test (PCT), and verbal learning test (RAVLT) were found to increase indicating increase in executive function , visuospatial function, and verbal learning and memory of the children with the enhancement of age of the age. The ruler drop test shows a decrement of with the age from 5 to 10 years representing an increase of reaction time of boys and girls. The hand eye coordination of the children was also enhanced with the advancement of age as the scores of the peg board score were increased. Age was significantly and positively correlated with cognitive skill and motor ability variables of the children.

On the other hand it was found that there was significant variation in the cognitive skill and motor abilities between boys and girls. It was noted that performance scores of tests of attention (CTT, CCT), phonemic fluency (FAS), and verbal learning and memory (REC, LOT) of girls were significantly ($p<0.001$) greater than that of the boys. On the contrary, visuospatial function (PCT) of the boys was significantly ($p<0.001$) greater than girls.

Linear regression analysis demonstrated that the age of the children was associated with the score of different cognitive and motor variables. Multiple regression analysis demonstrated that after adjustment the effect of height, weight BMI, socioeconomic status, age had strong significant impact on the scores of different cognitive and motor variables.

The variation of performances of cognitive skills and motor abilities of the children with the nutrients intake were studied. The result revealed that the quantity of nutrient intake such as, protein, carbohydrate, calorie, folic acid, choline, and omega 3 fatty acid was significantly correlated with the scores of cognitive skills and motor ability variables of the children.

The result of nutritional status of the children, as determined by the BMI, indicated that majority of the children belonged to normal (Boys 67.2% ,Girls 64.34%) and undernourished (Boys 25.16% , Girls 26.52%) category, and a very few children were belonged to overweight / obese category.

The results demonstrated that the scores of cognitive skill and motor ability of the children was significantly ($p<0.001$) higher in well nourished children compared to that of under-nourished and over-nourished children, as par BMI classification. Results of correlation coefficient revealed that BMI had strong significant ($p<0.001$) and positive correlation with all the score of cognitive and motor parameters except CTT, CCT, RT. It was found that BMI had negative and significant correlation with the score CTT, CCT, RT. As those were time parameters, negative correlation indicated better performances. Linear regression analysis demonstrated that BMI was strongly associated with the score of different cognitive parameters and motor parameters but multiple regression analysis indicated that after adjustment the effect of age height, weight, and SES, no significant impact of BMI on the scores of the cognitive skills and motor ability tests were found.

From the results it was observed that out of 445 boys 35.05% were stunted and out of 460 girls 37.17% were stunted. The comparison between scores of cognitive skills and motor abilities of stunted and non-stunted (normal) children revealed that the performances of the scores of the cognitive skills and motor abilities of non-stunted children were significantly higher ($p<0.001$) compared to the score of stunted children. Correlation coefficient of height with the score of different cognitive skill and motor ability variables were computed and result revealed that height was significantly and positively correlated with the score of all the cognitive parameters except CTT, CCT, and RT. The height had significant ($p<0.001$) and negative correlation with the score of CTT, CCT, and RT. The linear regression analysis demonstrated that height had strong significant association ($P<0.001$) with the score of different variables of cognitive skills and motor abilities. Multiple regression analysis demonstrated that after controlling the effect of age, height, weight, BMI, and SES, the height had no appreciable impact on the scores of cognitive and motor performances.

The socioeconomic status of the children was greater significant influential factors for cognitive skills and motor abilities of the children. The results revealed that the score of cognitive skill and motor ability of the children belonging to the lower socioeconomic status was significantly lower ($p<0.001$) than the scores of the children who belonged to middle and upper socioeconomic status. It was also noted that the socioeconomic parameters were significantly and positively correlated with all the score of cognitive and motor variables except CTT, CCT and RT; the CTT, CCT, and RT was negatively correlated with socioeconomic status. It was also revealed that socio demographic factors such as parental years of education, parental occupation, parental income and size of the family was strongly correlated with the score of different cognitive skills and motor ability variables. The results also demonstrated that CTT, CCT, and RT were negatively and significantly correlated with different socioeconomic factors. The family size had significant and negative correlation with the scores of FAS, PCT, REC, LOT, and peg board test for DH, and NDH, Both hand. Linear regression analysis demonstrated socioeconomic status was associated with the score of different cognitive and motor parameters. Multiple regression analysis after controlling the effect of age, BMI, height and weight, demonstrated that the SES had significant impact on the scores of cognitive and motor parameters.

The growth pattern of different cognitive and motor parameters was studied and it was noted that growth of the variables was linear with the advancement of age. The growth of those variables was comparable with that of physical growth of the children.

The percentile growth curves for different cognitive and motor ability parameters were drawn. Different percentile values, viz., 5^{th}, 15^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles were computed and shown in the growth curves. The 15^{th} percentile and 90^{th} percentile values were taken as the lower and upper cut-off values for motor and cognitive parameters of the children.

The norms for cognitive skills and motor abilities were determined by employing curve grading method and those were divided into five grades such as A, B, C, D, and F, which were designated as ‘Excellent’, ‘Very good’, ‘Good’, ‘Average’ and ‘Poor’ respectively. For representing the norms, the whole age group (5-10 years) of the children was divided into three groups, instead of six age groups, such as 5-6 year,7-8 year and 9-10 year. The graded norms for each of the cognitive and motor parameters may be treated as reference value of boys and girls of primary school children in Bengali population.

It was concluded that the cognitive and motor variables of the primary school children were found to vary as a function of age. There was also gender variation in cognitive and motor function parameters of the children. The said variables were noted to be changed with the nutritional status of the children. The cognitive and motor variables had significant difference between stunted and normal children. Different socioeconomic factors, such as, number of family members; parental education and composite socioeconomic status were the influencing factors for cognitive and motor performances of the children.

The followings are the main Achievements of the study:

- A database of different cognitive skill and motor ability parameters of the Bengali children has been formed.
- The percentile growth of different cognitive skill and motor ability parameters of the Bengali children has been established. Such growth chart will be helpful for assessing cognitive and motor growth status of any boy or girl of the Bengali primary school age children. Thus it would be possible to identify abnormal cognitive and motor growth of the boys and girls. Developmental Indicators for the children which assesses motor, cognitive, and language skills, school assessments, are mainly useful for testing if a child is experiencing developmental delay or disabilities.

- In the present investigation normative data for cognitive skills and motor ability parameters of the Bengali population have been formed. The parameters of the norms for cognitive skill and motor ability that help to determine the measures of the developmental progress of children such as behavior, reflexes, and responses. Further grading of the norms of different parameters has been done. The scores were divided into five grades such as A, B, C, D, and F, which were designated as 'Excellent', 'Very good', 'Good', 'Average' and 'Poor' respectively. The grading was done separately for different age groups as well as for boys and girls.

Such graded norms will be helpful for categorizing each of children according to their cognitive performance. Selection of children for interschool academic competition will be easier to achieve success. Graded norms, especially of motor skill parameters, will be a guide for selecting the students for different indoor and outdoor sports events.

On the other hand, according to the grading of cognitive and motor parameters, the children with poor or lower score may be identified and special emphasis may be given on them. Some suitable training may be arranged for betterment of their skills.

8.0 Conclusions

Chapter VIII

Contents

8.0.Conclusions

8.1 .General conclusion:

The present investigation demonstrated that performances of cognitive skills and motor abilities of the primary school children vary according to variation of the age and sex of the children and score of the cognitive skills and motor abilities were significantly correlated with age of the children. It was noted from the result that visuospatial function and verbal learning and memory was gradually increased with the increment of age. It might be due to age related gradual improvement of articulatory loop and articulatory process of the brain. Another key component might be articulatory loop and episodic buffer. The main function of the episodic buffer was to integrate the information from the articulatory and visuosaptial loop. It might be the increment of the functional activity of the episodic buffer due to enhancement of age.

It was noted that the score of visuospatial function was significantly greater in the boys compared to girls of the same age group. On the contrary it was also noted that the skills of verbal learning and verbal memory of the girls were better than that of boys. The facts were explained with the findings of different studies cited in the literature. Functional asymmetry, higher regional cerebral blood flow and cerebral metabolic rate in females compared to males might be possible causes for better cognitive performances in female. Another reason might be the significant patterns of differential activation occurred in the tasks of visuospatial function and verbal learning and memory between male and female subjects. The females had greater bilateral activation during a phonological language task along with the greater lateralization occurred in the left hemisphere during a working memory task. Female might have more frontal activation, compared to more parietal activation in males, during a verbal learning and verbal memory task and showed that males had a greater bias towards right hemisphere activation and female had a greater bilateral regional cerebral blood flow in temporal regions during performance of the memory recall or verbal learning and memory. Greater activation along with greater blood flow in partial lobe might be cause of better performances of visuospatial function in boys.

The scores of executive function such as, colour trail test, colour cancellation test, and FAS phonemic fluency test of both boys and girls were gradually increased due to advancement of age. The gradual improvement of the myelination and synaptic density might be the cause of better performances of executive function. Another cause might be the step wise maturation of the grey matter and white matter in the brain.

The performances of executive function was significantly greater in girls compared to that of boys which might be due to greater loss of grey matter in both sexes and gradual development of white matter, but rate of loss of grey matter in girls were slower than boys and age related atrophy in the boys were greater than girls of the same age.

In the present study it was noted that the motor ability of the primary school children was gradually increased with the advancement of age. It was also observed that the motor ability of the girls were significantly better than boys. Gradual improvement of cortex and cortico-spinal tract along with continued growth of corpus calosum and thalamo-cortical tracts and myelination of different areas of central nervous system might be possible cause of age specific motor development of the children.

Nutrition was an important factor that played a crucial role for cognitive and motor development of the children. The results of the present study showed that the malnutrition (under nutrition or over nutrition) affected the cognitive skills of the children. The underweight and overweight /obese children had significantly lower cognitive skills in comparison to their normal counterparts. Longer reaction time was noted in thinness and overweight / obese children compared to normally nourished children. It might be due to the fact that underweight children had been attributed to majority of preclinical dementia and disregulation of hormonal secretion. In case of overweight / obese children the brain health might be affected by the presence of adipose tissue that secreted cytokines and growth factors and this might be the possible causes for longer reaction time of overweight / obese children.

Hand eye co-ordination of overweight or obese children was lower than normal weighed children. Overweight and obese children might face more difficult to move their limb or larger body mass against the gravity.

Chronic protein energy malnutrition (stunting) resulted in cognitive impairments as well as slowing in the rate of the development of cognitive processes. Rate of development of cognitive functions might follow different patterns in children with malnutrition. Chronic protein energy malnutrition might affect the development of cognitive processes differently during childhood years rather than merely showing an overall cognitive dysfunction as compared to adequately nourished children. Stunting might result in delay in the development of cognitive functions as well as in permanent cognitive impairments which show minimal improvement with increase in age. Rate of development of attention, executive functions like cognitive flexibility, working memory, visuospatial functions like visual construction was more severely affected might be due to protein energy malnutrition in childhood years, a period that is marked by rapid ongoing development of cognitive functions. Cognitive deficits might be in conjunction with a poor home environment that could act as mechanisms of social exclusion as they further limit these children’s learning opportunities. Early childhood stunting was might related with poor performance in fine motor functions involving rapid sequential continuous finger and hand movements, and children with poorer function were at greater risk of lower cognitive and academic ability.

Socioeconomic status was important influential factors for development of cognitive skills and motor abilities of the children. In the present study it was found that performances of the cognitive skills and motor abilities of the children belonging to lower socioeconomic status was significantly lower than the children of middle and upper socioeconomic status.

Stress was an important factor that was very much common in lower socioeconomic children. It might be due to the fact that children living in stressful environment had smaller brain size and fewer cell body and dendrite and synapse. In case of children belonging to higher socioeconomic status might have higher brain volume due to increase number of capillaries and glial cell large no of dendrite and synapse. SES disparities not only affect cognitive function of the children but also hamper motor ability of the children. Slower neuromuscular reaction in the children with lower SES might be the reason for poorer performances of the children. Parental years of education, parental occupation and income and family size might be other important determining factors for lower performances of motor ability of the children belonging to lower socioeconomic status.

8.2. Testing of hypothesis:

In the present investigation some statistical hypothesis was generated. With experimental results all the hypotheses were tested.

It was hypothesized that the cognitive skills and motor abilities of the children would not be changed in variation to age of the children. The results of the study rejected the null hypothesis and the alternative hypothesis was accepted which indicated that the cognitive skills and motor abilities of the children were found to vary at different age group. The null s hypothesis was that there would not be any gender difference in cognitive skills and motor abilities of the children. The results of the study indicated that there was a significant difference in cognitive skills and motor abilities the between boys and girls and so the alternative hypothesis was accepted. It was further hypothesized that there should not be any difference in the cognitive skills and motor abilities with the variation of nutrient intake in the children. From the experimental results the null hypothesis was not accepted because the cognitive skills and motor abilities of the children were found to vary significantly with the variation of nutrient intake in the children. So the alternative hypothesis was taken. It was hypothesized that there would be no difference in cognitive skills and motor abilities with the variation of BMI of the children. The experimental results revealed that a greater degree of variation of cognitive skills and motor abilities of the children was found in the variation of BMI. Thus the null hypothesis was rejected and the alternative hypothesis was accepted. Similarly it was hypothesized that there should not be any difference in cognitive skills and motor abilities in between stunted and non-stunted children. The results of the study shown that there were significance differences in the cognitive skills and motor abilities between the stunted and non stunted children, thus null hypothesis was rejected and alternative hypothesis was accepted.

Another important statistical hypothesis of the study was that the cognitive skills and motor abilities would not be changed with the changes of socioeconomic status of the children. From the results of the study it appeared that the null hypothesis cannot be accepted. In the experimental study it was found that cognitive skills and motor abilities of the children were noted to vary significantly with the variation of socioeconomic gradient. Thus the alternative hypothesis became true.

8.3. Limitations of study:

Current study had certain limitations.

- The selected subjects of the present study were limited to Bengali population from three different districts in West Bengal.
- In this present study parameters related to anatomical and volumetric changes in the children as a function of age, sex, nutritional status, and socioeconomic status has not been studied.
- The neuroanatomical and neurophysiological studies for supporting the results could not be performed. The findings of other investigation available in the literature were used for explaining the results.
- In the present study a cross sectional design was used to investigate developmental differences of the children. A longitudinal study was not implemented because it was time consuming for completing the study. There are limitations associated with using cross-sectional data, as in every cross sectional study, conclusion related to cause and effect cannot be drawn. Cross sectional study provide only general estimation of different factor variation developmental changes, longitudinal study provide a stable measurement of individual changes over time.

- In the present study different factor affecting nutritional status were not studied. Some potential factors such as mother at first birth, Mother's BMI, preceding birth interval, diarrhoea episode, type of food consume and method of feeding, etc., were not studied.

8.4. Future Directions of study:

There are scopes for extending the present study. Some of them are pointed out.

- The study may be extended to include the subjects of different environmental conditions. The subjects from coastal areas as well as hilly areas of West Bengal may be selected to study the variation of cognitive skill and motor ability parameters of Bengali children with different environmental habitat.
- The study may be further extended to study the growth of cognitive skill and motor ability parameters of adolescent Bengali children of 11 years to 19 years. Such study would indicate the variation of cognitive skill and motor ability parameters of Bengali children due to change adolescence related factors. It may also indicate whether there is any growth spurt in cognitive skill and motor ability parameters of Bengali children.
- The present study may be extended to find association of development of cognitive skill and motor ability parameters with academic performances in their classes.
- Further study may be planned to investigate how physical activity level of the children is associated with cognitive skill and motor ability parameters of Bengali children
- Studies may be designed to investigate the effect of different hormones on cognitive skill and motor ability parameters of the children
- It has been noted the nutritional status was a definite influencing factors on cognitive skill and motor ability parameters of the children. However, certain factors related to the nutritional status of the children may be studied for better explanation of experimental results. Body compositional parameters of the children may associated with cognitive skill and motor ability parameters of the children.
- Future research should capitalize on experimental paradigms to isolate the mechanisms involved in nutrition and cognitive performance. Biological analyses, such as examination of the roles played by lipids, ghrelin, and leptin in eating habits, should also be

considered. These physiological measures are associated with obesity, hunger, nutrition and health and can be isolated in experimental studies to understand mechanisms by which nutrition impacts learning. Follow-up studies testing nutrition, stress, cortisol, and anxiety and learning, attention, and concentration are currently underway in order to extend the cognitive domains.

- Neuroscience research has made significant technological advances that permit for better examination of brain-behavior relationships. Advances include the use of functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), and salivary biomarkers such as cortisol, both brief, non-invasive strategies that provide a wealth of information about underlying physiology. Given these advances, future research should incorporate these paradigms when examining the relative impact of nutrition and other parameters on physiological processes needed for learning. By incorporating multi-method approaches, investigators will be able to better understand the issue under investigation.

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List of Publications

FULL PAPER Publication:

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2. Manna S., Pal A., Dhara P.C.(2016): Effect of socioeconomic status on learning ability of Bengali (Indian) primary school children. *Advances in Applied Physiology*, 1(1): 11-17. doi: 10.11648/j.aap.20160101.13.

3. Majumder A., Manna S., Koshy A.K., Biswas H.M. (2015): Impact of LEAD on muscle and joint pain of people working in plastic sector. *Irjmsh,* 6(12): 318-325.

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Reprints

VARIATION OF COGNITIVE SKILL ON AGE AND SEX OF PRIMARY SCHOOL CHILDREN OF WEST BENGAL.

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ABSTRACT

The cognitive growth of the children is an important phenomenon along with the physical growth. The purpose of the present study was to investigate the influence of age and sex on visuospatial function and the ability of learning and memory among 5-10 years school going boys and girls. A cross-sectional study was conducted on 905 school going children of which 445 was boys and 460 was girls from different districts of West Bengal state, India. Visuospatial ability of the children were evaluated by Picture completion test (PCT). The Learning ability of the participants was evaluated by Ray's auditory verbal learning test (RAVLT). The result showed that performances of visuospatial skill increases with the advancement of age in both sexes but the performances of boys were significantly ($p<0.001$) greater than that of the girls. The results of RAVLT revealed that the 5 years old boys and girls recalled significantly lesser words on each of the learning trials and showed significantly lower learning score compared to that of older boys. It was also found that performances of girls were significantly greater than that of the boys. Age was significantly ($P<0.001$) and positively correlated with verbal learning and memory, and visuospatial scores of both boys and girls. Multiple regression analysis demonstrated that even after controlling the effect of the height, weight, BMI and socioeconomic status the age had strong significant impact on visuospatial skill (PCT) learning of trials (LOT) and recognition (REC).

Key words: Age, Sex, Cross sectional study, Visuospaial function, Learning abilities.

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INTRODUCTION

Cognitive development of a person means perception, thinking and understanding the world through the interaction of genetic and learned factors. Different areas of cognitive development are information processing, reasoning, intelligence, language development, and memory. Brain development is an organized and highly dynamic multistep process, which is genetically determined, epigenetically directed and environmentally influenced (Tau and peterson.2010). This process continues both through childhood and adolescence, the developmental period during which the body and brain emerge from an immature state to adulthood (Spear. 2000., Steinberg. and Morris,2001). Although total brain size is approximately 90% of its adult size by age six, it is now well known that the gray and white matter subcomponents of the brain continue to undergo dynamic changes throughout adolescence (Giedd et al.1999.,Paus.2005).

The Rey Auditory Verbal Learning Test (RAVLT) was a commonly used measure of a person's ability to encode, consolidate, store, and retrieve verbal information (Schmidt, 1999). While the RAVLT has been found to be a sensitive test of verbal learning and memory (Tuokko., Kristjansson. and Miller. 1995., Petersen et al., 1999) performance has also been found to be affected by age, education, intelligence, and, albeit inconsistently, by gender (Schmidt. 1996). The declines in performance of RAVLT with age are well documented (Bolla-Wilson and Bleecker, 1986; Crossen and Wiens, 1994). The effect of education, IQ, and gender on RAVLT performance has been mixed, but it was generally accepted education and IQ affect performance and, when there is a difference, women perform slightly better than men (Schmidt 1996; Uchiyama et al., 1995).

Gender differences in cognitive abilities have been widely analyzed in the psychological and neuropsychological literature (Halpern.1992., Hedge and Nowell.1995.,Kimura.1999.,Weisis et al.,2003). Three major differences in cognitive abilities between men and women have generally been reported: (a) higher verbal abilities, favouring women; (b) higher spatial abilities, favouring men; and (c) higher arithmetical abilities, also favouring men. However, differences in calculation abilities have, at times, been interpreted as a result of men's superior spatial abilities (Geary.1996); hence, these three differences could be reduced to just two. Nonetheless, gender differences in children's cognitive abilities remain an area of controversy. Whereas some studies have found such differences, others have not been able to isolate them. There is no question that additional analyses of the potential gender differences in cognitive development are needed. These analyses should include a large sample with an ample age range, which may help to clarify the interaction between gender and age in relation to cognition. The aim of the present study was to analyze gender differences in verbal learning and memory, and visuospatial function of the primary school children as well as to study the pattern of growth of cognitive charecteristics with the advancement of age .

Methods and Materials:

Sites and Subjects:

A cross-sectional study was conducted on 905 school children of which 445 were boys and 460 were girls. They were selected within the age group of 5-10 years from different districts of West Bengal state, India. The eligibility of criteria for recruitment of the participants for the present study were boys having age 5 to 10 years, apparently healthy, and not suffering from any kinds of psychiatric or neurological disturbances. Participants with background of acute or chronic diseases were excluded from the study. For more precision, those participants who were taking psychotropic medication for at least last three weeks were excluded in the present study. The protocol of the present study was explained verbally in local language (Bengali) and informed consent was obtained from the parents. Ethical approval and prior permission were obtained from the institutional Ethics Committee before commencement of the study and the study was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration.

Ray's Auditory Verbal learning Test (RAVLT)

The RAVLT (Bleecker et al.1988) is a neuropsychological test of verbal learning and episodic declarative memory. The RAVLT was used to produce scores that measured short-term auditory verbal memory, rate of learning, learning strategies, retroactive, and proactive interference, presence of confabulation of confusion in memory processes, retention of information, and differences between learning and retrieval. In this experiment a list of 15 words (list A) was read loudly to the subject for consecutive 5 times. Each of the attempts was consisted of test of spontaneous retrieval. After the completion of fifth attempt, a list of interference, also consisted of 15 words (list B), was read to the subject and after reading of the words the students were asked for its retrieval (attempt B1). After attempt B1, the examiner instructed the individual student to recall the words which was belonged to list A, without reading the list again the individual student was instructed to recall it again (attempt A6). For the evaluation of learning curve of the words during attempts A1 to A5, the learning rate during the attempts –learning of trials (LOT) was calculated by the following formula:

Sum of A1 to A5 - (5 x A1)

After an interval of 20-minutes, the examiner again asked the individual to remember the words that were belonged to list A, without reading the list (attempt A7). After the attempt A7, the individual was asked to attend for the test of memory recognition, in which a list that consists of 15 words from list A, 15 words from list B along with 20 distracting words (similar to the words in list A and B in phonological or semantic terms) were read to the individual. Then each of the word read aloud, the individual was asked to indicate if the word belongs to list A, or not. The total time for application of the RAVLT ranged from 35 to 40 minutes. The total sum of attempts, from 01 to 05, and the rates of proactive interference were calculated by (B1/A1); retroactive interference was calculated by (A6/A5) and forgetting speed was calculated by (A7/A6). The result of the memory recognition test was calculated by adding the correct answers (when the individual correctly identified that the word belonged /did not belong to list A) – 35 (total of distracting words). This same procedure, used in recognition memory tests, allowed to evaluate not only identification of targets (words in list A), but also took into account the effect of false positives (identification of distracting words) and false negatives (unidentified words in list A).

Picture completion test:

It is a measure of visuoconceptual ability, visual organization and visuo-conceptual reasoning. It consists of 20 cards with pictures of different objects with a missing feature. The participants are required to name or point out to the missing feature. Number of correct responses comprises the score (Malin.1969).

Statistical analysis:

Descriptive statistics, including means and standard deviations, were calculated for all the variables. To test the significant difference of the variables, the t- test was performed. Pearson's correlation coefficient (r) was computed to test the association of all the variables. One-way analyses (Scheffe's procedure) were carried out to test for differences in Rey's auditory verbal learning test (RAVLT) and picture complitation test performances across the different age groups. To address the potential for confounding, regression analyses was undertaken. Age of the participants was entered into the model as independent variables. Age was included in the model as independent variables against RAVLT performances (LOT and REC) and visuospatial performances (PCT) as dependent variables after adjusting the effect of age. P-value set at <0.05 level. Statistical analyses were performed using the statistical software IBM SPSS version 20.

Results

The performance of cognitive skills of the primary school going children has been presented in Table 1 according to the age of the subjects. From the results it was revealed that there were significant variations ($p<0.001$) of simple scores of cognitive ability among the children of different ages. There was general tendency of increasing the scores of most of the variables with advancement of age.

The results of Bonferroni post hoc analysis showed that the boys and girls of lower age group (5 years) performed significantly lesser ($p<0.001$) score on each of the cognitive task and showed significantly lesser ($p<0.001$) visuospatial function (PCT) and verbal learning and memory (LOT,REC) compared to that of the boys and girls of 6 to 10 years. On the other hand, the 10 years old boys and girls performed significantly greater score ($p< 0.001$) than that of other age groups.

Table 1: Scores (Mean ±SD) of different cognitive parameters of boys and girls of the age groups 5 -10 yrs

			PCT		REC		LOT	
Age(yrs)	Boys (n)	Girls (n)	Boy	Girl	Boy	Girl	Boy	Girl
5	67	75	3.38±0.98	2.45±1.04	5±1.41	5.84±1.98	6.37±2.63	6.90±2.57
6	76	80	3.68±1.15	2.68±1.19	6.90±2.66	7.27±2.50	7.26±2.88	7.91±3.28
7	79	72	3.78±1.00	2.87±1.05	6.94±1.83	8.62±1.95	8.35±2.80	9.15±3.20
8	83	80	3.90±1.15	2.95±1.11	7.29±2.96	8.78±2.15	9.45±4.45	9.56±3.62
9	74	70	4.13±0.96	3.10±1.35	7.97±3.00	10.44±2.18	9.48±3.75	10.40±3.18
10	66	83	4.25±1.33	3.31±1.27	9.28±4.48	11.26±3.03	10±4.00	11.03±3.51
F ratio			5.46***	5.15***	16.07***	55.56***	11.55***	17.28***

*p<0.05,**p<0.01,***p<0.001.[PCT- picture completion test. REC- recognition LOT-learning of trials]

Correlation coefficient of cognitive parameters with age has been presented in Table 2. Correlation analysis demonstrated that age of boys and girls was significantly (P<0.001) and positively correlated with all the scores of cognitive task such as picture completion test (PCT) and recognition (REC) and learning of trials (LOT).

Table 2: Correlation coefficient of cognitive parameters of studied participants with age

Cognitive parameter	Boy	Girls
PCT	0.240***	0.230***
REC	0.371***	0.608***
LOT	0.330***	0.396***

*p<0.05,**p<0.01,***p<0.001 [CTT- colour trail test,CCT- colour cancellation test, PCT- picture completation test.. REC- recognition, LOT-learning of trials]

From the linear regression analysis of age with different cognitive parameters such as picture completion test (PCT) and verbal learning and memory test (LOT, REC) it was revealed that the age had significant association with different cognitive parameters (Table 3,4). Multiple regression analysis demonstrated that even after controlling for the effect of the height, weight, BMI, and socioeconomic status the age showed strong significant impact on all the cognitive parameters. Therefore, the age might be the best account for the variability of the cognitive performances.

Table 3 : Regression analysis of cognitive parameters with age (Boys)

Variables	Unadjusted						Adjusted #			
	B	SeB	B	R^2 change	F change	T	B	SeB	B	T
PCT Vs. Age	0.165	0.032	0.240	0.058	26.88	10.756 ***	**0.074**	**0.042**	**0.108**	**1.785**
REC Vs. Age	0.669	0.083	0.372	0.138	70.37	8.38 ***	**0.323**	**0.123**	**0.172**	**2.63****
LOT Vs. Age	0.745	0.101	0.331	0.110	53.99	7.34***	**0.336**	**0.148**	**0.149**	**2.26****

*p<0.05,**p<0.01,***p<0.001 [PCT -picture completion test ; REC- recognition ; LOT-learning of trials] #adjusted Height, Weight, BMI, & Socioeconomic Status

Table 4 : Regression analysis of cognitive parameters with age(female)

Variables	Unadjusted						Adjusted#			
	B	SeB	B	R^2 change	F change	T	B	SeB	B	T
PCT Vs. Age	0.161	0.032	0.230	0.053	25.66	5.066***	**0.221**	**0.0057**	**0.315**	**3.86 *****
REC Vs. Age	1.048	0.064	0.608	0.370	268.75	16.39***	**0.708**	**0.102**	**0.411**	**6.92 *****
LOT Vs. Age	0.813	0.088	0.396	0.157	85.22	9.23***	**0.641**	**0.160**	**0.312**	**3.99*****

*p<0.05,**p<0.01,***p<0.001 [PCT -picture completion test ; REC- recognition ; LOT-learning of trials] # adjusted Height, Weight, BMI, & Socioeconomic Status

Gender variation of cognitive skill has been presented in Table 5. The result showed that girls out performed boys in verbal learning and memory tests (Fig 2 and 3). It was found that performances of girls in verbal learning and memory was significantly greater (p<0.001) than that of the boys. On the contrary, the visuospatial function of the boys, which was presented by PCT (Fig-1), was significantly greater (p<0.001) than that of the girls.

Table 5 : Comparison of different cognitive parameters between boys and girls

Cognitive parameters	Boys	Girls
PCT	3.85*** ±1.13	2.89±1.20
REC	7.21±3.09	8.71*** ±2.97
LOT	8.50±3.70	9.17** ±3.53

* p<0.05, **p<0.01, ***p<0.001 [PCT- picture completion test. REC- recognition , LOT-learning of trials]

The growth curve of the picture cancellation test (PCT) showed that the scores of the test were gradually increased with the age of the children (Fig. 1) representing better visuospatial fuction of the boys and girls with the advancement of the age. The boys showed higher growth of this characteristic than that of girls.

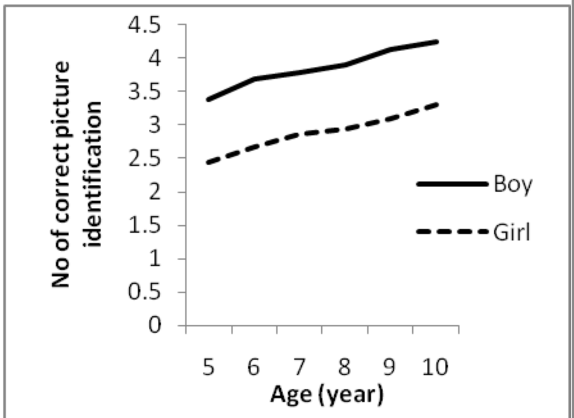

Figure-1: variation of visuaospatial function (PCT) in relation to age and sex of the children.

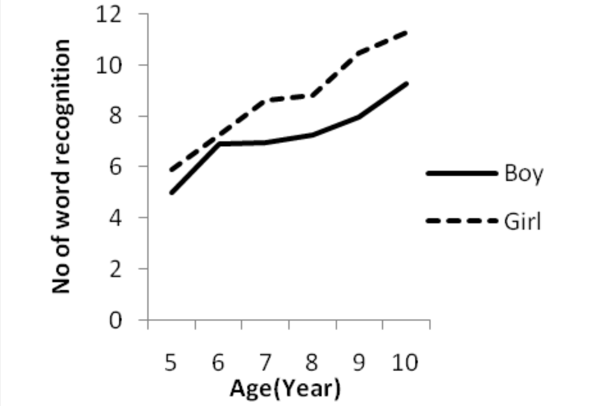

Figure-2: Variation of verbal memory (REC) in relation to age and sex of the children.

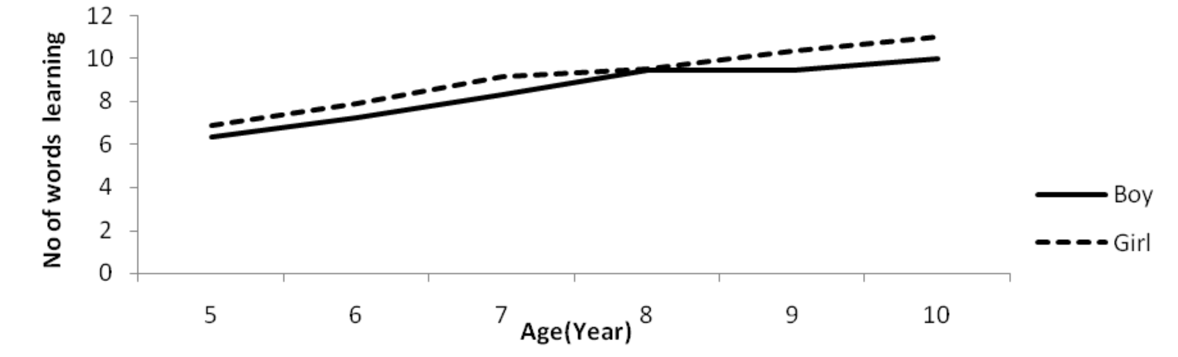

Figure-3: Variation of verbal learning(Lot) in variation to age and sex of the children.

From the Figs. 2 and 3 it was observed that the growth curves of the scores of learning of trials (LOT) and recognition (REC) showed upward shift with the increment of the age of the children. The pattern of the growth curve showed age related betterment in the ability of verbal learning and verbal recognition in boys and girls. In both the cases girls had better growth in those cognitive charecteristcs than that of the boys.

DISCUSSION

From the results it was noted that visuospatial ability, verbal learning and memory was gradually increased in both boys and girls from 5 years to 10 years of age. The articulatory process was the key component for gradual increase of verbal learning and memory and it was reported the said process was gradually activated by means of articulatory loop with the advanced of age (Baddeley.2000., Manna et al. 2016). It was also pointed out that the better cognitive performance of young children was due to the activity of the two main components, viz, articulatory loop and episodic buffer (Baddeley.2000). The key function of the episodic buffer was to integrate the information from the articulatory and visuo-spatial loop along long-term memory material (Query and Berger.1980). Toga et al.(2000) confirmed in his studies that myelination of some part of the brain continued well into adolescence, whilst myelination occured earlier in other parts of the brain that coordinated more primary function . Investigator had reported that grey matter reached asymptote by the age of 7-11 in different regions of the brain and growth of the white matter started to develop at earlier age and became matured at the age of 20 years of age (Giedd et al.2010). Studies also reported that maturation of brain area during childhood was associated with reading, learning and memory (Nagy et al. 2004., Deutsch et al. 2005). It had long been recognized that males and females exhibit differential performance on various cognitive tasks, including tests of visuao–spatial and verbal domains (Kimura.1996). Moreover, males and females experience different propensities for the development of neuropsychiatric disorders, may report different symptom profiles clinically, and present with altered levels of functioning and co-morbidity (Wilkinson and Robertson. 2006). These differences may reflect innate functional brain differences between the genders.

From the test of visuospatial ability (picture completion test) it was found that boys outperformed girls and from the tests of verbal learning and verbal memory girls outperformed the boys . The findings of this study was similar to that of the findings of other studies, where it was suggested that boys outperformed girls in visuospatial ability (Halpern et al.2007.,Moreno-Briseno et al. 2010) From the results (Table 5) it was also noted that performances of verbal learning and verbal memory in girls was better than that of boys. This findings was supported by other studies (Kimura. 1996) which also suggested that females performed better than males in tasks of verbal learning and memory.

Li et al. (2004) demonstrated that functional asymmetry, cerebral metabolic rate and cerebral blood flow in females was higher than that of males using the techniques of PET and SPCET. More recently, functional imaging studies and functional magnetic resonance imaging (fMRI) studies were conducted to investigate gender influence upon regional brain activity changes and the changes of regional cerebral blood flow occurred during stimulus presentation and it was reported that there were significant patterns of differential activation in between the sexes in tasks of visuospatial function and verbal learning and memory (Fischer et al. 2004.,Lee et al.2005). Gender specific alterations in brain activation was observed in insular and thalamic regions, frontal region (Lee et al. 2005) , occipital and cingulate regions (Fischer et al. 2004) , parietal regions (Weiss et al. 2003) and temporal regions (Ragland et al. 2000). An altered lateralization between the hemispheres was also reported (Ragland et al. 2000). It was suggested that females have greater bilateral activation during a phonological language task (Lee et al. 2002., Georgopoulos et al. 2001). Additionally, females had more frontal activation, compared to more parietal activation in males, during a verbal learning and verbal memory tasks (Weiss et al. 2003). Males had greater bias towards right hemisphere activation (and females to left hemisphere activation) during a task requiring a judgement of a whole object from its parts (Georgopoulos. 2001). The female had a greater bilateral regional cerebral blood flow in temporal regions during performance of memory recall or verbal learning and memory (Ragland et al. 2000).

Studies had suggested that males perform better than females on tests of visuospatial functioning (Kimura.1996). However, the difference in performance between these groups was not accompanied by significant alterations in functional activation. Greater parietal activation in males and greater frontal activation in females was reported (Weiss et al.2003).

Previous studies suggested that males performed better than women in cognitive measures of visuospatial ability. In the present study it was found that in general girls performed better than males in tests of verbal function (Kimura. 1996). However, in other studies Bell et al. (2005) reported that significantly increased in activation of the regions that involved in carrying out a verbal fluency task in males compared to females . A regional analysis revealed that a greater BOLD signal magnitude was observed in males compared to females in several brain regions (Bell et al. 2006). Structural brain differences and brain composition differences influence the BOLD signal, as well as regional cerebral blood flow, blood volume, and cerebral metabolic rate of oxygen was reported.(Vogt et al. 1992). Visual stimulation in males and females contain a greater number of undetectable BOLD signals were present in males than in females were established (Marcar et al. 2004) . In a similar investigation, reported that decreased BOLD signal response in females during binocular visual stimulation, compared to males (Levin et al. 1998),that might be reason for lower visuospatial function of girls compared to that of boys.

Conclusion

The neuro-cognitive development was found to be directly related to age and sex of the children. The cognitive parameters, viz., visuospatial and verbal learning and memory, were found to be increased with the advancement of age of the boys and girls. The visuospatial skill was greater in boys than that of girls but the ability of learning and memory was higher in girls than that of boys.

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Effect of Socio-Economic Status on Learning Ability of Bengali (Indian) Primary School Children

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Abstract: Socioeconomic status is strongly associated with the cognitive ability and achievement during childhood. The purpose of the present study was to investigate the influence of age and socioeconomic status (SES) on learning ability among 5-10 years school going boys. A cross-sectional study was conducted on 322 school going boys from different districts of West Bengal state, India. The socio-economic status of the participants was evaluated by modified Kuppuswami scale. Learning ability of the participants was evaluated by Ray's auditory verbal learning test (RAVLT). The subjects were divided into lower, middle, upper SES groups. The results revealed that the 5 years old boys recalled significantly lesser words on each of the learning trials and showed significantly lower learning score compared to that of older boys. Age was significantly ($P<0.001$) and positively correlated with RAVLT performances. The participants belonged to the lower socioeconomic group recalled significantly lesser words on each of the learning trials and possessed significantly smaller learning score compared to that of middle and upper socioeconomic groups. Correlation analysis demonstrated that socioeconomic status had significant and positive correlation with RAVLT performances. On the contrary, age and socioeconomic status had significant negative correlation with forgetful speed. Multiple regression analysis demonstrated that even after controlling for the effect of the age, socioeconomic status had strong significant impact on learning of trials (LOT) and recognition (REC).

Keywords: Socioeconomic Status, Cross Sectional Study, Learning Abilities, Recognition

1. Introduction

Socioeconomic status (SES) of a person depends on the level of income and other social factors. However, economic status is a major factor related to the SES. Socioeconomic status refers to an individual's position within a social structure. It is one of the important determinant factors for the health status. Socioeconomic status is the combination of the social and economic variables. Several methods have been used for classifying different population by socioeconomic status such as Rahudkar scale 1960 [1], Udai Parikh scale 1964 [2], Jalota scale 1970 [3], Kulashrestha scale 1972 [4], Kuppuswami scale 1976 [5], Srivastava scale 1978 [6], Bharadwaj scale 2001 [7]. Kupuswami scale proposed in 1976 that measures socioeconomic status based on three variables such as education, occupation and household income [5]. Socioeconomic status influence the quality of physical and psychological environment throughout development [8]. The psychological research established that poverty is powerful risk factor for poor developmental outcomes [8] and poor cognitive and school performances [9].

Socio-economic status is strongly associated with the cognitive ability and achievement of the children. Poverty has a significant effect on neuro-cognitive development, thereby limiting of the educational opportunities that compromise the social relationship required for socio-economic development [10, 11]. The children who are living in a low income household or low socio-economic family, associated with deprivation of nutrient, maternal malnutrition of early sensory stimulation as well as exposure of environmental toxin [12-14]. Living in poverty is also associated with poorer overall physical health, and having greater chance for mental disorders, affecting attention and anxiety and mood. Socio-economic status is the combination of education, income and occupation. The family of low socio-economic status have great difficulties to access a wide range of resource to promote and support of young children health and education as well as resources for social, emotional and cognitive development [15]. The studies also related that memory system induces medial temporal structures including hippocampus that's are important for memory consolidation and retrieval [16]. In several studies it was indicated that the memory and the performance were strongly and directly correlated with socio-economic status [17].

The memory is defined as the group of abilities that involves in acquisition, storage and retrieval of different type of information. The long term memory that allows the storage of information for a long periods of time where as short term memory that allows the storage of small quantities for a short period of time [18]. The working memories is defined as the memory system that involves storage and manipulation of information for performing wide variety of activities such as reasoning comprehensive and repetitive task [19].It has three subdivision - articulatory loop, visuo-spatial sketch pad, and central executive. The articulatory loop is responsible for processing and temporarily retaining the speech and knowledge. Several factors may affect the working memory, including educational level, sex and age [20].Several test has been applied to evaluate the learning and memory. One of the most important test frequently referred to international literature is the "Ray's auditory verbal learning test' [21], that is employed to evaluate the memory and learning. The Rays auditory verbal learning test measures the recent memory, verbal learning susceptibility to interference (proactive and retroactive), retention of information after a certain periods of time during which other activities are performed and recognition memory.

The purpose of the study was to investigate the influence on age and socio-economic status on learning on the basis of the performance on Ray's auditory verbal learning test (RAVLT) in male children having age range of 5-10 yrs.

2. Methods and Materials

2.1. Sites and Subjects

The socio-economic status (SES) of the participants was evaluated by modified Kuppuswami scale [22] considering the educational level, occupation and economic condition of the family and was expressed in terms of socioeconomic Scale. The socioeconomic status was determined by the scores suggested in this scale. The score obtained by each participant in education, occupation and income were added to get the final score and accordingly the participants were categorized. The subjects were categorized into three socioeconomic groups on the basis of SES scores, as shown below:

SES score 1-15: lower socioeconomic group
SES score 16-25: middle socioeconomic group
SES c score 26-29: upper socioeconomic group

2.2. Ray's Auditory Verbal learning Test (RAVLT)

The RAVLT [23] is a neuropsychological test of verbal learning and episodic declarative memory. The RAVLT was used to produce scores that measured short-term auditory-verbal memory, rate of learning, learning strategies, retroactive, and proactive interference, presence of confabulation of confusion in memory processes, retention of information, and differences between learning and retrieval.

In this experiment a list of 15 words (list A) was read loudly to the subject for consecutive 5 times. Each of the attempts was consisted of test of spontaneous retrieval. After the completion of fifth attempt, a list of interference, also consisted of 15 words (list B), was read to the subject and after reading of the words the students were asked for its retrieval (attempt B1). After attempt B1, the examiner instructed the individual student to recall the words which was belonged to list A, without reading the list again the individual student was instructed to recall it again (attempt A6). For the evaluation of learning curve of the words during attempts A1 to A5, the learning rate during the attempts – learning of trials (LOT) was calculated by the following formula: Sum of A1 to A5 - (5 x A1).

After an interval of 20-minutes, the examiner again asked the individual to remember the words that were belonged to list A, without reading the list (attempt A7). After the attempt A7, the individual was asked to attend for the test of memory recognition, in which a list that consists of 15 words from list A, 15 words from list B along with 20 distracting words (similar to the words in list A and B in phonological or semantic terms) were read to the individual. Then each of the word read aloud, the individual was asked to indicate if the word belongs to list A, or not. The total time for application of the RAVLT ranged from 35 to 40 minutes. The total sum of attempts, from 01 to 05, and the rates of proactive interference were calculated by (B1/A1); retroactive interference was calculated by (A6/A5) and forgetting speed was calculated by (A7/A6). The result of the memory recognition test was calculated by adding the correct answers (when the individual correctly identified that the word belonged /did not belong to list A) - 35(total of distracting words). This same procedure, used in recognition memory tests, allowed to evaluate not only identification of targets (words in list A), but also took into account the effect of false positives (identification of distracting words) and false negatives (unidentified words in list A).

2.3. Statistical Analysis

Descriptive statistics, including means and standard deviations, were calculated for all the variables. To test the significant difference of the variables, the t - test was performed. Pearson's correlation coefficient (r) was computed to test the association of all the variables. One-way analyses (Scheffe's procedure) were carried out to test for differences in Rey's auditory verbal learning test (RAVLT) performances across the different groups. To address the potential for confounding, regression analyses was undertaken. Age and socioeconomic status of the participants were entered into the model as independent variables. Socioeconomic status was included in the model as independent variables against RAVLT performances (LOT and REC) as dependent variables after adjusting the effect of age. P-value set at <0.05 level. Statistical analyses were performed using the statistical software IBM SPSS version 20.

3. Results

The performance of Rey's auditory verbal learning test (RAVLT) of the primary school going boys has been presented in Table 1 according to the age of the subjects. From the results it was revealed that there were significant variations (p< 0.05 or less) of simple and composed scores of RAVLT among the children of different ages, excepting proactive interference (ITP) and forgetful speed (VE). There was general tendency of increasing the scores of most of the variables with advancement of age.

The results of post hoc analysis showed that the boys of lower age group (5 years) recalled significantly lesser (p<0.001) words on each of the learning trial (A1to A7) and showed significantly lesser (p<0.001) learning score (SUM) compared to that of 6 to 10 years old boys. On the other hand, the 10 years old boys recalled significantly more words (p< 0.001) than that of other age groups. Correlation analysis demonstrated that age was significantly (P<0.001) and positively correlated with all the simple and composite scores of RAVLT except proactive interference (ITP) and retroactive interference (ITR). On the contrary, age had significant (P<0.05) negative correlation with forgetful speed (VE).

Table 1. *Mean ± SD of RAVLT performances cores by age groups.*

AGE (yrs)	A1	A2	A3	A4	A5	A6	A7	ITP	ITR	VE	SUM	REC	LOT
5(n=46)	3.692± 1.08	3.891± 1.48	4.239± 1.18	5.108± 1.25	5.673± 1.41	3.108± 0.82	3.282± 0.75	0.771 ±0.26	0.567 ±0.16	1.097± 0.27	22.282 ±5.18	4.652± 1.19	5.434±3.17
6(n=54)	5.03± 1.92	5.732± 2.19	6.714± 2.34	7.875± 2.75	8.535± 3.29	4.678± 1.60	4.928± 1.55	0.718 0.23	0.580± 0.20	1.087± 0.22	33.892 ±11.98	6.143± 2.25	6.734±2.39
7(n=58)	4.810± 1.71	5.724± 1.67	6.568± 1.66	6.931± 1.82	7.775± 2.07	3.982± 1.34	3.931± 1.34	0.689 0.33	0.525 ±0.16	1.007± 0.22	31.810 ±8.16	6.689± 1.82	6.224±3.39
8(n=62)	5.080± 1.25	5.870± 1.34	6.661± 1.29	7.139± 1.57	7.741± 1.61	4.483± 1.41	4.654± 1.20	0.753 0.29	0.596± 0.17	1.056± 0.19	32.548 ±5.87	6.661± 2.56	7.258±3.24
9(n=54)	6.555± 1.66	7.518± 1.91	8.814± 1.85	9.743± 2.22	10.481 ±2.48	5.351± 1.34	5.370± 1.68	0.706 0.15	0.526± 0.15	1.008± 0.22	43.074 ±8.71	9.407± 2.42	9.055±5.62
10(n=46)	7.326± 2.51	8.656± 2.75	9.695± 2.58	10.782 ±2.85	11.869 ±3.03	6.021± 1.59	5.934± 1.55	0.773 0.23	0.513± 0.08	1.003± 0.19	48.239 ±13.22	10.891 ±3.61	10.413±4.43
FRatio	30.912 ***	34.043 ***	50.308 ***	43.450 ***	40.011 ***	27.719 ***	23.200 ***	1.048	2.446*	1.992	47.076 ***	44.596 ***	11.757***

*p<0.05, **p<0.01, ***p<0.001 [ITP-Proactive interference, ITR-Retroactive active interference VE-Forgetful speed, SUM-Addition of scoresfromA1-A5, REC-Recognition, LOT-Learning of trials].

In the present study the socioeconomic status (SES) of the study participants was assessed by modified Kuppuswami scale and the study participants were categorized into lower, middle and upper socioeconomic groups. From the results it was noted that about 30% of the participants were belonged to the lower socioeconomic group, 36% were belonged to the middle socioeconomic group and remaining 34.47% of the participants were belonged to the upper socioeconomic group. The scores of RAVLT of the primary school going boys were compared in variation to socioeconomic status (Table 2). The results of ANOVA showed a significant variation (p<0.001) in auditory verbal learning performances of the participants among different socioeconomic groups excepting proactive interference (ITP) and retroactive interference (ITR). From the results it was appeared that the performance scores were gradually increased from lower to higher SES, excepting ITP and VE. It was noted that there was a gradual decrease in the mean scores of VE (p<0.01) and ITP (non-significantly). The post hoc analysis showed that the participants belonged to the lower socioeconomic group recalled significantly lesser words on each of the learning trials and significantly lower learning score compared to that of middle and upper socioeconomic groups (Table 2). The boys belonged to upper socioeconomic group recalled significantly more words than that of lower and middle socioeconomic groups.

Table 2. *Mean ± SD of RAVLT performance score by socioeconomic status (SES).*

RAVLT Performance	Lower SES (n=96)	Middle SES (n=115)	Upper SES (n=111)	F ratio
A1	4.08±1.65	5.17±1.69*	6.63±2.12*##	50.35(p<0.001)
A2	4.75±1.7	6.08±1.88*	7.58±2.53*##	47.788(p<0.001)
A3	5.59±1.86	6.97±1.93*	8.55±2.67*##	47.038(p<0.001)
A4	6.17±1.91	7.7±2.19*	9.61±2.94*##	53.64(p<0.001)
A5	6.78±2.04	8.54±2.48*	10.35±3.36*##	44.879(p<0.001)
A6	3.5±1.26	4.56±1.26*	5.59±1.53*##	60.474(p<0.001)
A7	3.7±1.33	4.7±1.38*	5.5±1.6*##	39.753(p<0.001)
ITP	0.76±0.32	0.73±0.25	0.71±0.17	0.824(NS)
ITR	0.53±0.18	0.55±0.15	0.57±0.17	1.049(NS)
VE	1.1±0.28	1.05±0.21	0.99±0.17*#	5.46(p<0.01)
SUM	27.38±8.43	34.44±9.09*	42.72±12.99*##	53.554(p<0.001)
REC	5.33±1.75	7.08±2.14*	9.39±3.59*##	60.191(p<0.001)
LOT	5.09±3.01	7.45±3.64*	9.5±4.35*##	35.343(p<0.001)

w.r.t.Lower*p<0.001. w.r.t.Middle#p<0.05; ##p<0.001.

Correlation analysis demonstrated that socioeconomic status (SES) had significant and positive correlation with auditory verbal learning performances except proactive interference (ITP) (Table 3). On the contrary, socioeconomic status had significant (P<0.001) negative correlation with forgetful speed (VE). Such findings were noted among the boys of individual age groups as well as in composite groups of all ages. In composite group there was strong correlation (p<0.001) in all variables excepting ITR (p<0.05) and ITP (NS).

Table 3. *Correlation coefficient between socioeconomic status and Rey's auditory verbal learning performance scores.*

Age	A1	A2	A3	A4	A5	A6	A7	ITP	ITR	VE	SUM	REC	LOT
5	0.291*	0.302*	0.432**	0.596***	0.602***	0.625***	0.323*	0.105	0.039	-0.414**	0.554***	0.41**	0.407**
6	0.69***	0.682***	0.703***	0.765***	0.687***	0.753***	0.708***	-0.257	0.0023	-0.252	0.738***	0.830***	0.48***
7	0.616***	0.603***	0.613***	0.552***	0.498***	0.707***	0.655***	-0.006	0.349**	-0.141	0.628***	0.551***	0.45***
8	0.388**	0.349**	0.292**	0.327**	0.352**	0.34**	0.15	0.187	0.072	-2.294	0.413***	0.47***	0.426***
9	0.294*	0.445**	0.385**	0.339**	0.392**	0.598***	0.565***	0.172	0.258*	0.13	0.434***	0.691***	0.436***
10	0.854***	0.843***	0.832***	0.899***	0.884***	0.814***	0.716***	-0.491	-0.112	-0.183	0.896***	0.885***	0.826***
All	0.501***	0.497***	0.471***	0.493***	0.48***	0.587***	0.513***	-0.037	0.135*	-0.194***	0.515***	0.546***	0.465***

p<0.05*p<0.01**p<0.001***.

Linear regression analysis of socioeconomic status with learning of trial (LOT) and Recognition (REC) was performed and it was revealed that socioeconomic status had significant association with LOT and REC (Table 4). Multiple regression analysis demonstrated that even after controlling for the effect of the age, socioeconomic status had strong significant impact on LOT and REC. Therefore, the socioeconomic status might be the best account for the variability of the auditory verbal learning performances.

Table 4. *Regression analysis of socioeconomic status as independent variable and REC and LOT are dependent variables.*

Variables	Unadjusted						Adjusted#			
	B	SeB	β	R^2change	Fchange	T	B	SeB	β	t
REC	0.202	0.017	0.546	0.298	135.757	11.65***	0.182	0.013	0.49	13.86***
LOT	0.229	0.024	0.465	0.216	88.109	9.38***	0.213	0.023	0.432	9.32***

***p<0.001 # after adjusting age.

4. Discussion

The age and SES influenced the scores of all the sub-items. The study revealed that age and SES showed significant effect on learning and memory. The performance of simple scores A1 to A5, and composite scores (LOT, REC) revealed that recalling of words was gradually increased in both children of upper socio-economic and lower socioeconomic families. This improvement might be attributed to the learning which was mainly achieved due to the repeated reading of the word list.

The immediate recall performance (A1) was influenced by the age independently. The articulatory process and the articulatory loop were the key components of the working memory, whose function was to hold the auditory information in the form of memory. It was found that the increase of age (from 5 to 10 years) had a positive effect on the articulatory loop and articulatory process and there was a strong positive relationship between early recall (A1) and performance of school children [24, 25]. The delayed recall (A7) was also influenced by age. Investigators proposed that the better performance of young children was due to the activity of the two main components, viz, articulatory loop and episodic buffer [26]. The key function of the episodic buffer was to integrate the information from the articulatory and visuo-spatial loop along long term memory material [27].

In the present study the socio-economic status showed an effect on learning process of the children. The level of SES affects emotion, and cognitive development in various degree [28-30]. Other studies [31, 33, 36-37, 39] also showed that the SES of childhood affect the cognitive development which had a positive co-relation with intelligence and academic achievement from the childhood to adolescence. Previous studies pointed out some factors that might have indirect effects on learning process of the children. A higher rate of depression, anxiety, and attention problem were observed among the children with lower SES back ground in comparison to that of higher SES back ground [29, 32-35, 38]. Several studies found that SES had extreme affect on various newer cognitive system such as language processing and moderate affect on the working memory and cognitive control [30, 40, 42]. Language problem and phonological awareness were also noted as an effect of SES [43]. It was postulated that SES was positively correlated with the functions of inferior frontal gyrus which was activated during language task [44]. The study also showed decreased language function of the left hemisphere in the children with low SES. The SES related difference in executive function of working memory has been noted in children and adult. The SES influenced verbal and spatial working memory in the children and adolescents and working memory in late childhood [30, 40, 41].

Efforts have been made by different investigators to explain the influence of socioeconomic status of the individual on the learning process in terms of neurological functions. The poverty affects the five consecutive cognitive functions such as language, executive function, memory, spatial cognition and visual function [45]. The left perisylvian region and other region of the temporal cortex involved in semantic, phonological and grammatical processing of language [46, 47].The medial temporal area including hippocampus was found to be significantly important for the consolidation of memory and retrieval [48]. Harman and Guad -agno showed in their studies that performance at memory task was strongly and directly co-related with SES [49]. The frontal cortex was highly susceptible to the negative effect of SES disparity [50]. Further, more studies revealed that parental SES was associated with delayed maturation of prefrontal cortex, impulsive decision making, delayed attention [51] and deficit of variety of cognitive ability, such as reading, learning, and language, that persisted into adulthood [50, 51]. Brain having the capacity to rapid growth and changes that occurred into first 5 yrs of life, for that purpose necessary of adequate nutrient, and nurturance and care of a parents, and social climate for normal development were suggested [50, 52, 53]. In rich SES condition, the enriching activities such as learning and cognitive task that caused the growth of a new neurones in hippocampus, on the contrary, the stressful environment caused the opposite effect on hippocampus i.e. decrease the neurogenesis on that region [54-57].

5. Conclusion

The neuro-cognitive development was found to be directly related to socio-economic status. Low socioeconomic status was associated with decrease in the functioning of executive control, memory and language processing and decreased in the development of brain regions that were involved in socio-emotional processing. Poverty affects the neural development. Correlation analysis demonstrated that socioeconomic status had significant and positive correlation with RAVLT performances. Lower socioeconomic status had significant negative correlation with forgetful speed. The severely low socioeconomic condition can be harmful for the children who are the future citizen of the country.

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