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Prediction of cognitive and intellectual competence in kindergarten schools associated with general measures of health: a study on children with age ranges between 4 to 7 years

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PREDICTION OF COGNITIVE AND INTELLECTUAL COMPETENCE IN KINDERGARTEN SCHOOLS ASSOCIATED WITH GENERAL MEASURES OF HEALTH: A STUDY ON CHILDREN WITH AGE RANGES BETWEEN 4 TO 7 YEARS

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ABSTRACT:

BACKGROUND
Stunting refers to the low "height-for-age" measurement. Literature suggests that it is associated with delayed or diminished physical development, cognition and intellectual abilities.

OBJECTIVES: This study aimed to estimate the physical growth measures among children under 4 to 7 years of age and to determine its relationship with cognitive deficits & intellectual performances.

METHODOLOGY: This cross-sectional study was conducted on a sample of 300 students from different government and private schools under 4 to 7 years of age. The anthropometric measuements and cognitive and intellectual skills were assessed using the Wechsler Intelligence Scale (WISC-R) subtests Block Design and Digit Span (cognitive examination) respectively. Subsequently, Wide Range Assessment Test (WRAT-R) (Reading and spelling age) was used to check sensory-motor intelligence (intellectual examination). SPSS Version 22.0 was used for statistical analysis.

RESULTS: Out of the total, 36.5% were males, and 63.4% were females. The measurement of physical reliability was good, i.e. 48.93±3.12 (m) for mean head circumference, mean Body Mass Index (BMI) was 48.93±3.12 kg/m2 and 17.07±2.12 for arm circumference. In a block design, 49.3% (n=148) children showed poorer cognitive functioning to focused on the task. In digit span, 77.3% (n=232) children showed forward digit span tasks, and many children were unable to repeat two items in reverse orders. Spelling test reflected the phonologically plausible misspellings among children. In Reading, 80.3% (mean=3.77) students showed a Mean distractions and 19.6% shown complete loss of concentrations. Overall, the quality of reading was not very good, as reflected by an increased number of distractions.

CONCLUSION: It is concluded that stunting affects both the physical and mental health of the children as it significantly alters the cognitive and intellectual abilities together with delayed physical development. Only preventive measures (i.e. appropriate nutritional management) during the early childhood years can help in avoiding such deficiencies.

KEYWORDS: Cognitive memory, intellectual tasks, school readiness, BMI, socio-economic status, nutritional adequacy, physical measures.

INTRODUCTION: Child health focuses on the overall wellbeing of the child from all the stages of the child lifespan. It ranges from conception to the adolescent. , which is important in all the aspects, i.e. a child has to achieve optimal height-for-age[1]. It is evident that the anthropometric measurements are the major indicators of childs chronic health. The major indicators of anthropometric measurements include height, weight , BMI, waist circumference and mid-arm circumference, body's muscle composition, and skin-fold thickness, , etc[2]. Growth less than the optimal range of these indicators is indicative of malnutrition, and if persistent over a prolonged period of time, this severe nutritional deprivation leads to stunting (i.e.[3]. Children can be categorized as malnourished if their arm circumference falls below an arbitrarily specified level[4]. Parental

monitoring and support are two factors that have consistently been identified as positive predictors for controlling malnutrition among adolescence[5,6]. Moreover, socio-economic status (SES) and parental education also lead to poor health, due to scarcity of material resources[5,6]. People with low SES have low educational opportunities[6,7]. A child is considered 'stunted' if his or her height is more than two standard deviations below the standard provided by WHO8. The main causes of stunting include intrauterine growth retardation, inadequate nutrition to support the rapid growth and development of infants & young children[9]. Frequent infections during early life lead to stunting, as it begins in utero. A very short height usually reflects the persistent, cumulative effects of poor nutrition and other deficits that often span across several generations. The main causes that lead to stunting are malnutrition, infection and mother-infant interactions[9]. A report indicates that since its creation, Pakistan has effectively controlled poverty with reduction from 64% to 25% by the end of 2016[10]. Despite such reduction in poverty, according to a Health survey 2018, still, one in every three children born in Pakistan are stunted . In other words, nearly 38%, of the unde-five children are stunted. Pakistan still stand among the countries with the highest stunting rate worldwide[11]. Apart from malnutrition, the stunted growth and low birth weight might result in response to early induction of labor, multiple pregnancies, infections and chronic conditions such as diabetes and high blood pressure (BP)[12].

Working memory plays an essential part in cognition. Moreover, the training on memory tasks focuses on broad cognitive changes, and this which has become the center of focus for a rapidly growing literature13. It is well-known evidence backed understanding that physical fitness and exercise influence the cognitive brain functions, i.e. exercise has a beneficial effect on enhancing the brain performance[14]. Several studies specifies the relationship between the undernutrition, wasting, stunting and academic achievement among children[15]. A Chinese study suggested that age-specific height for age (HAZ) is associated with the the child's grade level [16]. An improvement in height with an increment in 0.3 years showed better school grade-for-age16. Moreover, Kenyan children who were well-nourished had higher composite scores on a test of verbal comprehension[17]. Children admitted to school from kindergarten are usually more likely to be able to follow the classroom rules and routines, pay attention and persist at challenging tasks and enjoy school, graduate from high school, and find productive and sustained employment as compared those who lack these skills[18].

It is estimated that 40% of the children under 5 years of age among developing countries have low heights for age (stunting)[19]. Low birth weight and stunting during the early childhood period have been found linked with diminished adult human capital, with including compromised development in congnition, behavioral problems, and lesser schooling attainment, even after the confounding factors like parental schooling and Socio-economic status (SES) of the household are controlled[20]. Stunting has detrimental effects on the brain as it causes alterations in the temporal sequence of the brain maturation, which in turn disturbs the formation of neural circuits and result in cognitive deficits[21]. Primary skills (at school entry) such as letter recognition, spelling, and phonemic awareness as precursors to reading, and number recognition, magnitude understanding, and counting as precursors to mathematics are referred as generally developed abilities[22]. The preschool-age children who are experiencing delays in physical fitness (stunting), delayed intellectual, cognitive, communication, social, emotional, or adaptive development are often referred for a comprehensive assessment to make diagnostic determinations and to help develop appropriate interventions[22]. Undernutrition duing the infancy and early childhood phase is thought to have an adverse affect on the development of child's cognition[22]. To determine whether there is evidence of an independent association between the status of undernutrition and cognitive development, the differences in the educational capacity and socio-economic possessions available among the stunted and non-stunted children must be taken into consideration. This study aims to estimate the physical growth measures among children under 4 to 7 years of age and to determine its relationship with cognitive deficits & intellectual performances.

METHODOLOGY

This observational cross-sectional study was conducted during the period of April 2018 till January 2019. A total of 300 primary school students were selected from 6 different private & government schools for differentiation in the SES. All those children who were residing in Karachi, Pakistan with no history of any pathological conditions at the time of enrollment were included in the study. A written informed consent was gained from their parents. The data regarding demographic characteristics, anthropometric measurements and working memory examinations were collected using an internally developed questionnaire with the help of existing tools. Cognitive and intellectual tests were designed to evaluate the

mental functioning of children. For this, 3 subtests were used, i.e. Wechsler Intelligence Scale for Children (WISC-R), Wide Range Achievement Test (WRAT-R) and Schonell Spelling Test that is further sub-divided into Block Design, Digit Span, Reading and Spelling Age. We have assessed the cognitive abilities through Block design and Digit span to check the executive function of children. While-Reading test and spelling age test were used to check the academic coding's skills of the child, i.e. for Intellectual Examination.

For Block Design: The child was made to work directly on a block model, set up by the researcher. He/she was asked to see the blocks and respond if they were all alike. Some sides of the box were all red, and some were black. While mixing cards to show the different sides, the child was asked to watch it carefully. Cards were arranged on the respective block to form without exposing to the child. While the model remains intact, the stopwatch was started, and blocks were given to the child to design according to the model as much as 45 seconds. The time limits were given each child to complete block design was 45seconds. Any design which were not matched the model card by the child was counted as failure and 0 was given to them.

For Digit Span: There are two parts to the Digit Span test, Digits Forward and Digits Backward. Each child is given Digits forward if s/he obtains a score of 0 on Digits Forward. Then, proceed with Digits Backward until both trials of an item are failed. 2 points if the child passes both trials; 1 point if the child passes only one trial; 0 points if the child fails both trials.

For Reading test: This test involves recognition of letters and pronounces words out of context. In the reading test, a child is allowed to read a paragraph in a maximum of 3 minutes. While reading the given context, his/her concentrations and the number of distractions were noted by the researcher. The scoring was done maximumly after 3 minutes of assessment on the basis of a number of distractions and correctly spelt words.

For spelling Age (Schonell Graded Spelling Test): Children were given an empty sheet to write 15 words as dictated by the researcher from the schonell graded spelling test. The test was not timed, and children were required to respond to each word. The score was given to a child on the basis of numbers of the word spelt correctly that was implemented by using a formula: Spelling Age = no. of correctly spelt words + 5/10.

The collected data was then analyzed using SPSS Version 22.0. All qualitative variables were displayed using frequencies and percentages while for quantitative variables, the mean and standard deviation was used. The study was conducted in accordance with the ethical guidelines and declaration of Helenski.

RESULTS

Table 1 presents the demographic characteristics and anthropometric results of a total of 300 children. Of which, 49.6% of children were from low-to-middle SES, and 50% belonged to middle-to-high SES. There were no significant difference among 36.5% males and 63.4% females based on the mean anthropometric measurements. Moreover, the cognitive and intellectual scores of children were quite similar among the two genders.

Table 1: Demographic characteristics of the study population

Variables	Sub-categories	(n= 300)
Gender	Males	109(36.5)
	Females	189(63.4)
Schools	Private	151(50)
	Government	149(49.6)
AnthropometricMeasurements	Weight (kg)	17.58±4.49
	Height (m)	1.85±7.25
	BMI (kg/m ^{2})	13.23±3.78
	Head Circumference (cm)	48.93±3.12
	MUAC (cm)	17.07±2.12

*values are given as n(%) or Mean±SD
*BMI-Body Mass Index; MUAC-Mid-Upper Arm Circumference

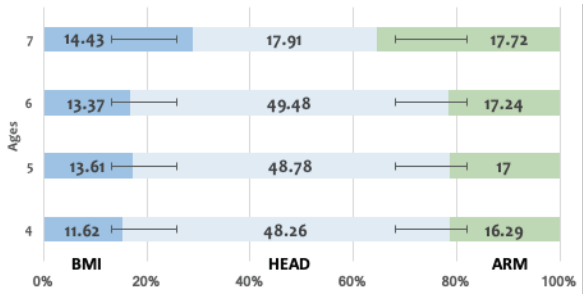

Figure 1: Mean Anthropometry of Children from 4 to 7 years of age

The mean anthropometrics increased with age, i.e. the mean BMI among four years children was 11.62 and 14.43 among those who were 7 years old. Same was in the case of arm circumference, as shown in figure 1.

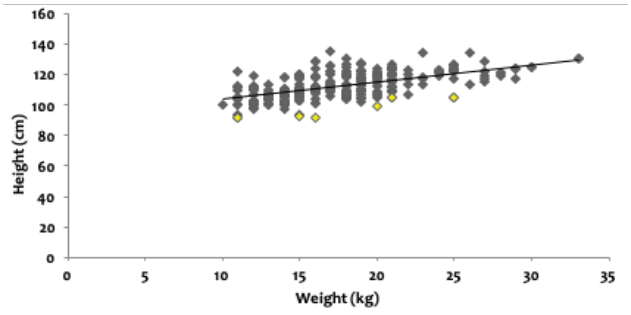

Figure 2:Shows the Weight-to-Height Score (WHZ)

Children with higher WHS (weight-to-height scores) i.e.

the children with less severe form of stunting, were more likely to experience a catch-up growth. At some points (colored yellow dots), some children showed a drop in WHS (stunted and underweight) due to inadequate nutritional factors and SES.

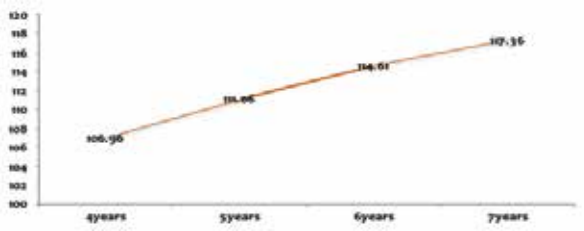

Figure 3: Height-to-Age Scores (HAZ)

Figure 3 shows a relative increase in height to age scores among all participants, which increased gradually with age.

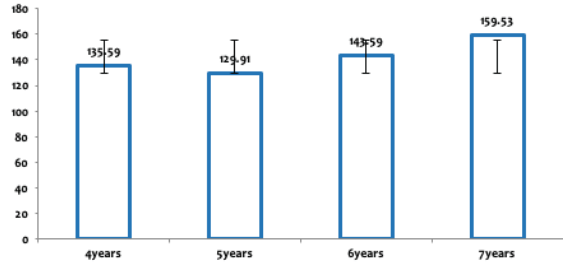

Figure 4: Reading Test scores and concentration according to ages

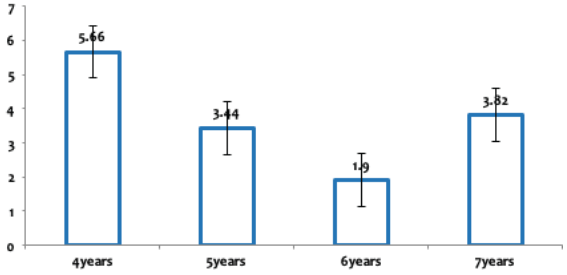

Figure 5: Shows the Mean Distractions among children according to age

Outcome measurements of concentrations during reading revealed that 4 and 5 years children scored two standard deviations (2SD) lower concentration-time than 6 and 7 years because of increased imaginative thinking and distractions.

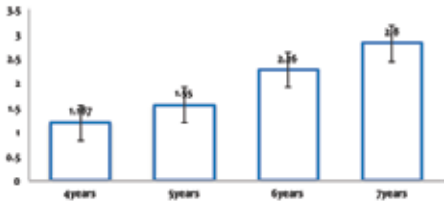

Figure 6: Mean Spelling age among children from 4 to 7 years

Figure 5 shows the phonologically plausible misspellings from lower to the higher end of the scale. This effect was because there were fewer easy words to spell than difficult words: children spelled more words above their grade level and lesser words below their grade level.

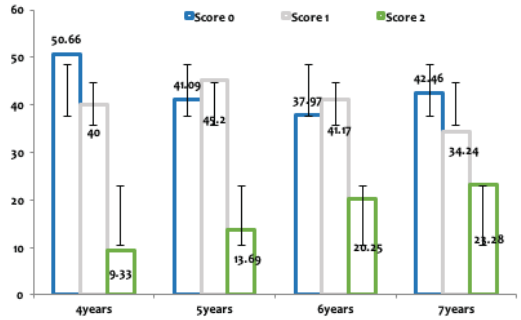

Figure 7: Shows the mean block design Scores according to age

Most of the children under 4 to 5 years scored 0 and showed poorer cognitive functioning to focused on the task due to distractions during the game, while an increasing trend was observed with age.

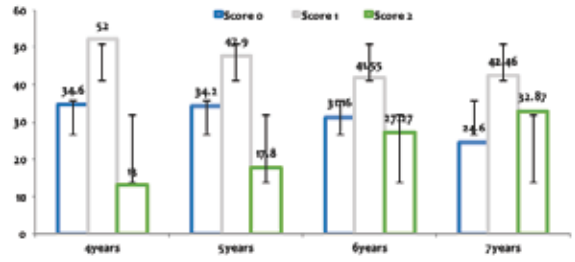

Figure 8: Digit Span (forward and backwards)

Failure in the Digit span tasks was observed among children aged 4 or 5 years, and many children were unable to repeat two items in reverse orders. However, with increasing age, tasks were made possible by children showing the cognitive skills that were implicated by the child's working memory, executive functioning and visual-spatial memory according to age.

DISCUSSION

The study evaluated the association between mental wellbeing and physical health among school-going children of different SES. Based on the WHO growth standard charts for male and female children, the prevalence of stunting was spotted out as 70% . The questions about the SES of the family were asked verbally from parents and about a child's nutrition. Some of the children were having low birth weight, iron-deficiencies and stunting due to the low family income, rent houses and unemployment (Table 1). Some children have good family status and a healthy nutritional status, but due to genetic errors, their WHZ scores were below than normal (Figure 2). Maternal health, paternal unemployment, parent schooling, undernutrition, schools with compromised teaching performace, late academic achievements showed direct effects on stunting. However, from the results of another study, it is expected that if likely mediators such as nutrition, breastfeeding, weaning, morbidity (including untreated paediatric HIV infection, and accessibility to health services were available, the effect of SES could be seen on child's overall health and wellbeing [23]. Some children have good family status (defined on the basis of family's health, SES, employment status etc.) and a healthy nutritional status (based on different health related variables), but due to genetic errors, their WHZ scores were below than normal. International guidelines on infant and young child feeding support breastfeeding up to and beyond 2 years[24]. This study revealed that prolonged duration of breastfeeding is a risk factor for stunting. It seems paradoxical that children who were breastfed more than 2 years paradoxical were at high risk of stunting. Nonetheless, the fact that most mothers started complementary feeding after 12 months gives an explanation for this result. Mothers who ceased breastfeeding before 1 year probably started giving additional foods at the recommended age. Although the prevalence of stunting in this study was slightly lower among all but the association was not statistically significant. It has been analyzed during the survey that children studying in higher schools have bad schooling and academic achievements due to ill brain growth that made them leads to mental stunting. Some findings were also notified that the part of the effect of maternal education on child health outcomes was explained by SES. In addition, we accounted for about 49.6% of parent's education effect on child nutritional status because of their geographical residence, SES, attitudes for health care, health knowledge and poor schooling and parent's illiteracy. The authors from a similar study indicated that individual-level and community-level factors greatly attenuate the influence of maternal education on stunting and infant mortality, but maternal education remains strongly associated with child health (mental and physical). Our finding is similar, except for modern healthcare utilization[25]. Stunting analysis was more strongly associated with the child's cognitive test performance. Stunting in the first 2 years of child's life, particularly when it is severe, was strongly associated with cognitive test scores at ages 8 and 11 years. This finding is consistent with earlier research suggesting that short stature in early life is associated with poor cognitive development later in childhood[26]. In our study, models were run to assess the association between stunting and cognitive-motor performance. The effects of cognition during games were constant; all the children showed positive performance with increasing age and focused mind task. The games were given for the specific time to complete. Few children showed a deficit in test scoring and were significantly associated with stunting (Figure 4-8). Reduced schooling was an important factor contributing to the poor intellectual development of children stunted in the first 2 years of life. After adjusting for schooling, associations between stunting in the first 2 years and later cognitive development were strongly attenuated. In this cross-sectional study, as expected, children stunted at age 4 years had a marked delay in reading and writing spelling tasks and are more likely to experience in low mental growth that leads to stunting (Figure 4-6). The association between concurrent stunting and poor school progress or cognitive ability is evident. Stunted children, compared with non-stunted children, were less likely to be enrolled in school, more likely for delayed enrolment and to attain lower achievement levels or grades for their age and have the poorer cognitive ability or achievement scores[27]. In summary, these results suggest that there might be an effect of stunting on cognitive and intellectual activities as demonstrated that children can recover from early nutritional insults and suggest that catch-up growth contributes to cognition. The importance of executive function and working memory skills in academic achievement has been found that inhibitory control aspects of executive functioning were uniquely related to a range of measures of academic ability.

CONCLUSION

Children should be given appropriate care, and methodological effort should be aimed at improving

quality health. It has been noted that high SES greatly participate in the learning of children while families with low SES were least likely to be involved in the education of their children. Low parental SES has a negative effect on the academic performance of children might be due to financial challenges. Children from government schools were found to be poorer spellers than children in private schools. Furthermore, our results remained significant after statistically controlling for the comparison of SES and both verbal and non-verbal intellectual skills that measure a child's frontal lobe functioning. It is important to identify what are the most important actions to be taken to make better progress, and what research be done to assist with these decisions. Observational longitudinal studies are necessary to resolve these issues of stunting that contributes to education outcomes and cognition functions.

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Yusra Saleem; data collection, data analysis, manuscript writing, manuscript review
Muhammad Bilal siddiqui; data collection, data analysis, manuscript writing, manuscript review
Sahmoon Noushad; data collection, data analysis, manuscript writing, manuscript review
Sadaf Ahmed; data analysis, manuscript writing, manuscript review