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Socioeconomic status is a predictor of neurocognitive performance of early female adolescents

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Abstract:
Objective: Previous studies have shown that high socioeconomic status (SES) is significantly associated with inhibitory control, working memory, verbal comprehension and IQ. However, in the Asian setting, with its prevailing poverty, information about the influence of SES on cognitive development of female adolescents is limited. This study was aimed to investigate the association between SES and neurocognitive performance of early female adolescents in Sri Lanka.
Methods: Female adolescents aged 11–14 years (n = 200) of low and middle SES were studied to assess neurocognitive function. After obtaining baseline data, eight subtests of the Wechsler Intelligence Scale for Children (WISC – IV), Test Of Nonverbal Intelligence (TONI-3) and two computer-based executive function tests (inhibition and visuo-spatial working memory) were administered to assess neurocognitive measures of the above adolescents. The results were compiled into a data base and analyzed using SPSS version 20 statistical software.
Results: Higher SES was associated with higher performance in all neurocognitive tests. Low SES adolescents obtained significantly poor test scores for executive function test (inhibitory control: $p < 0.0001$) and for WISC [verbal comprehension index (VCI): $p < 0.0001$), working memory index (WMI): $p < 0.0001$ and estimated full scale IQ (EFSIQ): $p < 0.0001$)] when compared with middle SES adolescents. Maternal education alone significantly predicts VCI and EFSIQ than the combined influence of parental education, occupation and income. Psychosocial adversities of adolescents were inversely correlated with VCI ($r = -0.30$; $p < 0.001$) and EFSIQ ($r = -0.20$; $p < 0.001$) of WISC and mathematics performance ($r = -0.34$; $p < 0.001$) at examination in school.
Conclusion: Findings of the study revealed the importance of upliftment of SES of the society to improve the cognitive and academic outcomes of low SES individuals.

Keywords: early female adolescents, neurocognitive function, socioeconomic status, Sri Lanka
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Introduction

Adolescence is the transition of childhood to adulthood. It is divided into three developmental stages; early, middle and late. Age from 11 to 14 years is regarded as the early adolescence, the period generally begins with puberty and is characterized by physical, psychological, cognitive and social changes [1]. It is a period where the child experiences increased independence and develops peer relationships. Socioeconomic status (SES) is the social and economic standing of an individual that is measured by income, education and occupation. Parental SES is a proxy indicator of differences in environmental exposure. Thus, SES is associated with early life experiences which are critical in cognitive development. The brain undergoes a massive growth spurt in early adolescence producing substantial changes in behavior, cognition and learning and memory [2]. The prefrontal cortex (PFC) continues to mature from birth through adolescence to early adulthood with structural and functional changes [3]. PFC is highly involved in high order cognitive outcomes and is central for better

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academic achievement. The protracted maturation of PFC as indexed by synaptic reorganization and myelination provides opportunities to be influenced by environmental stimulation [4], [5]. Therefore experiences influenced by SES differences play a key role in shaping the neural architecture and morphology of the developing brain [6]. Cognition is the process, by which the sensory inputs are transformed, reduced, elaborated, stored, recovered and used [7] and it is the key for learning and the educational achievement of an individual.

To date studies indicate that SES disparities in children and adolescents are associated with disparities in a range of cognitive outcomes which include executive functions especially working memory and inhibitory control [8], [9], [10], [11], [12], language processing [11], [13], [14], school achievement [15] and IQ [16], [17]. A recent study conducted in the UK with a large sample of children through ages 2 to 14 years found greater variance in intelligence in low SES families due to moderation of the environmental effect [18]. Further to this, low SES is associated with poor physical and psychosocial wellbeing, impaired behavioral and emotional development [19], high prevalence of psychopathologies such as internalizing and externalizing behaviors [20], [21] and poor cognitive and academic performance [11], [22].

Studies on the effect of SES on cognitive development among Asian female adolescents are limited. Data from lower middle income countries such as Sri Lanka are remarkably scarce. Most of these previous studies were conducted in Western countries with higher socioeconomic and educational backgrounds. These Western studies' findings cannot be generalized in the Asian context due to ethnic, geographical and cultural differences. Health indices of a country are primarily assessed by the state of women's health. Therefore, the physical and psychological health status of female adolescents is vital. Especially, cognition of female children affects the productivity and socioeconomic state of a country directly and indirectly as female adolescents are the future mothers of a country. Considering these facts, the present study was aimed to identify cognitive outcomes associated with SES differences in the context of cognitive function.

Methods

A school-based descriptive cross-sectional study was carried out on randomly selected schools in the Galle educational zone in Sri Lanka. Galle is the main coastal city in the Southern Province with an adolescent population of nearly 30,000. The study population comprised of 200 female adolescents aged 11–14 years residing in the city of Galle. Schools were randomly selected to represent all categories of school classified by the Ministry of Education. They were selected from three types of schools categorized as type 1 AB, type C and type 2. The classes were randomly selected covering ages of 11–14 years. All students in each selected class were recruited. Children with medical conditions and acquired neurological disorders such as epilepsy, cerebral palsy and Down syndrome were excluded from the study. The study was conducted from July 2016 to July 2017. Seven participants were dropped from the study due to various reasons. All the cognitive function tests were administered in a quiet class room especially allocated for the researchers in selected schools. The trained data collectors specialized in the field of psychology, carried out a group of specific tests of the entire sample. Data collection was supervised by a licensed psychologist during preliminary data collection to ensure reliable data collection. Each test result indicated +1 or 0. Therefore, the final answers scores were not affected.

Ethical approval was granted by the Ethics Review Committee, Faculty of Medical Sciences, University of Sri Jayewardenepura. Permission was obtained from the school authorities prior to starting the data collection. Informed written consent from the parents and the assent of the child were taken prior to the start of data collection.

Study instruments

A self-administered socio-demographic questionnaire was used to assess educational level, employment status and income level of the parents. Parents' occupation was categorized based on criteria of the Hollingshead Index of Occupation Scale [23] matched as closely as possible to modern occupations. Adolescents who come from families with parental education not exceeding high school education with the occupation scale ranging from 4 to 1 corresponding to skilled manual workers, semiskilled workers and unskilled workers/unemployed, respectively, were categorized as "low SES". Families with monthly income below the mean (Rs 34,583.00/230 USD) of the sample were considered as low income families. Middle SES group was categorized as families having a family income greater than the mean income value and having at least one parent with education beyond secondary education and an occupation criteria ranging from 5 to 7 on the Hollingshead scale which corresponded to clerical and sales workers, technicians, semiprofessionals, small business owners and occupations of minor professionals, respectively.

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Psychosocially adverse factors of the subjects were assessed using an interviewer administered psychosocial adversity scale [24] which has been widely used in child development studies [25]. It assesses the home environment and the parents' health status. Total scores were taken as a measure of psychosocial adversity. Higher scores indicated higher levels of psychosocial adversity. Items were scored by interviewing the adolescent. Marks obtained for mathematics, science and Sinhala language (mother tongue) were taken from student school records to assess the academic performances as these subject examinations are conducted in all the schools as a common uniform examination by the Ministry of Education.

Different aspects of cognitive functions were assessed using the Wechsler Intelligence Scale for Children (WISC)- Fourth UK Edition (WISC-IV) [26], Test of Nonverbal Intelligence (TONI-3) and two executive function tasks. Each cognitive assessment test is described below.

The WISC-IV which is devised by the Psychological Corporation (USA), contains a widely used collection of intelligence tests that objectively assess various cognitive skills including language, attention, memory, problem solving, visuo-spatial and processing speed. It is also an individually administered clinical instrument for children aged between 6 years 0 months and 16 years 11 months. Eight subtests of cognitive functions were used to assess four cognitive indices namely: verbal comprehension index (VCI) (similarities, comprehension), working memory index (WMI) (digit span, symbol search), perceptual reasoning index (PRI) (picture completion, matrix reasoning) and processing speed index (PSI) (cancelation and arithmetic), so that there are two subtests for each of the indices. The Estimated Full Scale Intelligence Quota (EFSIQ) was determined based on the sum of scores of the eight subtests. The WISC profile has been validated in the Sri Lankan setting and has been used in previous national studies [27]. These subtests are user friendly and easy to administer in the Sri Lankan setting and were well accepted by the adolescents.

The TONI-3 is a test which is free of language and culture bias and an objective method of examination of cognitive function which does not require motor skills. It can be used on individuals aged between 6 and 90 years [28]. It has been in use since the 1970s and is well accepted as a valid test battery to measure abstract reasoning. It has 45 items arranged in order of difficulty per test.

Executive functions were tested using two tests with two computer games; the pig house paradigm which assesses the visuo-spatial memory task, and the stop signal paradigm which assesses the inhibition task.

In the pig house paradigm, a 4 × 4 matrix was displayed on a computer screen as a computer game. When a pig appears in each window one at a time, the participant was asked to report in reverse order the locations where each target (pig) had appeared. The test started with a span length of 2, that is, two pigs appeared one after another and each span length consisted of two trials, and the test was automatically stopped when the participant failed to respond to both trials at the same span length. One point is awarded for each correct response and zero for incorrect response. The total number of points was used as the measure of spatial working memory. Test-retest reliability of this test has been shown by Thorell and Whlstedt [29].

The inhibition task (stop signal paradigm), was administered as a car game. Every time a car appeared on the computer screen, the child was asked to press the space bar as quickly as possible when she saw a car on the computer screen, to drive away the car and not to wait for the STOP sign. The car was visible for 1500 ms while the inter stimulus interval was 4500 ms. Ten blocks were administered for each child. The mean number of incorrect presses at stop trials (commission errors) and stop signal delay were used as measures of inhibition.

The Statistical Package for the Social Sciences (SPSS) 20 version , Armonk, NY, IBM corp. was used to analyze the data. Each independent and dependent variable were checked for frequency distribution, skewness and normality. A multicollinearity test was carried with reference to Cohen and Cohen 2003 [30]. The composite scores of cognitive function test were transformed to a Z-score in order to present data on a common scale. Descriptive and inferential statistics are used to analyze the data. The subjects were grouped according to SES to determine the cognitive function test performances in groups. Multivariate analysis of covariance (MANCOVA) was applied to test the effect of SES on overall performances of cognitive function tests after controlling for age. A multiple regression test was done to predict the cognitive test performance based on construct of SES. The statistically significant level was considered as a p-value less than 0.05.

Results

The ages of the adolescent participants ranged from 11 to 14 years with a mean age of 12.2 (±1.16) years. The majority of the participants were Sinhalese (84.5%) by ethnicity and Buddhist (84.5%) by religion with 15.5% Catholics. There were equal numbers of participants from all types of schools categorized by the Department of Education. The sample was categorized as low and middle income based on criteria presented in Table 1.

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Table 1: Characteristics of low and middle socioeconomic status (SES) families in this study.

	Low SES (n = 112)	Middle SES (n = 88)
Mean age	12.22 (1.2)	12.21 (1.1)
Mean parental education, years	19.25 (7.5)	26.20 (6.0)[a]
Mean Hollingshead occupation score	2.17 (1.1)	4.6 (1.7)[a]
Mean income (USD per month)	177 (64.5)	338 (58.5)[a]
Psychosocial adversity score	3.55 (2.3)[a]	0.41 (0.8)

[a]$p < 0.001$; Mean parental education, income and occupation score of middle SES is significantly higher than low SES individuals.

When it was analyzed to see whether there was a significant effect of SES differences on all neurocognitive measures using MANCOVA with factors of SES and age as a covariate, it indicated a statistical significant effect of SES disparity on overall neurocognitive performance $F(8186) = 9.93$, $p < 0.0005$, Wilk's $\Lambda = 0.701$, partial $\eta^2 = 0.30$.

Participants showed their best performances for processing speed and working memory tasks of the WISC profile. When the nonverbal intelligence test was performed, the majority of the participants were average (48.8%) for TONI test performances while 29.4% and 13% were below average and poor, respectively (data not shown). An independent t-test was carried out to determine whether there are any significant differences between low and middle SES on the cognitive test performances. Table 2 summarizes the inferential statistics on SES disparities for the cognitive tasks. Low SES adolescents showed statistically significant poorer test scores for executive function tests (inhibitory control) and for WISC (VCI and EFSIQ) compared to middle SES adolescents ($p < 0.05$). In contrast there was no statistically significant difference between low and middle SES for the PRI and visuospatial test performances ($p > 0.05$).

Table 2: D-values, t-values and p-value for task and composite score.

Task	Low SES	Middle SES	D-value (effect size)	T	p-Value
Weschler Intelligence Scale for children scores					
Working memory index (WMI)	86.72 (13.33)	94.75 (10.87)	0.66	−4.55	0.000
– Digit span scale score	13.70 (2.9)	15.72 (2.8)	0.69	−4.86	0.000
– Arithmatic scale score	24.43 (3.75)	26.43 (2.4)	0.64	−4.32	0.000
Verbal comprehension index (VCI)	73.96 (12.41)	82.27 (11.9)	0.68	−4.75	0.000
– Similarities scale score	22.78 (6.19)	25.92 (5.75)	0.52	−3.65	0.000
– Comprehension scale score	22.59 (10.44)	25.44 (6.34)	0.44	−2.25	0.026
Processing speed index (PSI)	94.86 (20.65)	103.01 (11.34)	0.48	−3.32	0.001
– Cancelation scale score	83.64 (18.09)	86.89 (19.25)	0.17	−1.22	0.227
– Symbolic search scale score	24.35 (6.55)	27.01 (6.82)	0.39	−2.78	0.006
Perceptual reasoning index (PRI)	68.18 (10.29)	70.63 (7.46)	0.27	−1.87	0.063
– Matrix reasoning scale score	20.25 (4.91)	21.11 (3.92)	0.19	−1.33	0.184
– Picture completion scale score	20.82 (4.65)	22.08 (4.37)	0.27	−1.94	0.053
Estimated full scale IQ	75.91 (10.28)	82.23 (8.97)	0.65	−4.54	0.000
Test of nonverbal intelligence (TONI) scores					
– TONI raw score	18.50 (6.41)	21.43 (6.47)	0.45	−3.18	0.002
– TONI percentile	29.51 (22.38)	41.59 (26.0)	0.49	−3.51	0.001
Executive function tests					
– Visuo-spatial memory	20.34 (7.14)	22.31 (7.07)	0.27	−1.94	0.053
– Inhibitory control (stop signal delay)	266.36 (88.48)	186.64 (64.71)	−1.02	7.08	0.000
School performance test scores					
– Mathematics score	49.08 (19.09)	60.54 (19.82)	0.58	−4.17	0.000
– Science score	54.35 (19.19)	62.82 (17.46)	0.46	−0.29	0.002
– Sinhala (mother tongue) language score	65.66 (15.23)	72.32 (15.16)	0.43	−3.08	0.002

Univariate Pearson correlations (data not shown) indicate an inverse relationship between psychosocial adversities and scores of VCI ($r = -0.30$; $p < 0.001$), WMI ($r = -0.19$; $p < 0.05$), PSI ($r = -0.15$; $p < 0.05$), EFSIQ ($r = -0.20$; $p < 0.001$), nonverbal intelligence ($r = -0.19$; $p < 0.05$) and mathematics ($r = -0.34$; $p < 0.001$). Poor inhibitory control (increased stop signal delay) was associated with high psychosocial adversities ($r = 0.34$; $p < 0.001$). Working memory index (WMI) and EFSIQ were significantly correlated with all subject scores ($p < 0.001$).

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Multivariate analysis

Data were normally distributed and when the multiple regression analysis was performed, we examined the extent to which the SES accounted to each neurocognitive measure (Table 3). SES is a composite of parental education, occupation and income. Maternal education alone accounted for 22.5% variance in the VCI (β = 0.23; $p < 0.0001$). When the parental education, occupation and income were included to the model, 22.9% variance accounted for VCI and parental education (β = 0.43; $p < 0.001$) was statistically significant and occupation and income were not statistically significant, respectively. The EFSIQ maternal education accounted for 15.9% of the variance. A combination of parental education, occupation and income accounted for 18.4% of the variance in the model; parental education was statistically significant and occupation and income were not statistically significant. For inhibitory control maternal education accounted for 6.9% of the variance (β = −0.27; $p < 0.001$); in this case parental education, occupation and income were not statistically significant. Neither maternal education nor a combination of parental education, occupation and income significantly accounted for variance in the test of nonverbal intelligence and visuospatial memory. Family income did not account for variance in any cognitive outcome of early female adolescents.

Table 3: Regression demonstrating variance in cognitive composites account by individual indicators of SES.

Cognitive measure	Model	R-square	β
VCI	Maternal education	0.225	0.47^{c}
	Parental education	0.229	0.43^{c}
	Occupation		0.08^{ns}
	Family income		0.02^{ns}
PRI	Maternal education	0.072	0.27^{c}
	Parental education	0.090	0.30^{c}
	Occupation		-0.04^{ns}
	Family income		0.06^{ns}
WMI	Maternal education	0.066	0.26^{c}
	Parental education	0.099	0.26^{c}
	Occupation		0.09^{ns}
	Family income		-0.02^{ns}
PSI	Maternal education	0.067	0.26^{c}
	Parental education	0.082	0.19^{a}
	Occupation		0.14^{ns}
	Family income		-0.01^{ns}
EFSIQ	Maternal education	0.159	0.40^{c}
	Parental education	0.184	0.39^{c}
	Occupation		0.03^{ns}
	Family income		0.03^{ns}
TONI-quotient	Maternal education	0.018	0.14^{ns}
	Parental education	0.052	0.16^{ns}
	Occupation		0.07^{ns}
	Family income		0.04^{ns}
Visuospatial memory	Maternal education	0.007	0.08^{ns}
	Parental education	0.017	0.02^{ns}
	Occupation		0.12^{ns}
	Family income		0.01^{ns}
Inhibitory control (SSD)	Maternal education	0.069	-0.27^{c}
	Parental education	0.108	-0.13^{ns}
	Occupation		-0.20^{ns}
	Family income		-0.09^{ns}

Parental education includes both maternal and paternal educational level. ns, Non-significant. $^{a}p < 0.05$; $^{b}p < 0.01$; $^{c}p < 0.001$.

Discussion

This study was designed to link two separate fields namely neurocognitive science and sociology. The results indicate that neurocognitive performances were higher among female adolescents with higher parental SES compared to female adolescents of parents with low SES. SES difference is accounted for disparities in cognitive

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functions specifically for VCI, WMI,PSI, EFSIQ (inhibitory control) and nonverbal cognitive ability. As deficits in neurocognitive abilities are the foundation for academic under achievement among low SES background children [31], implications of research are presented to foster cognitive outcomes of low SES.

Most of the cognitive indices are correlated with maternal education alone than the combined influence of parental education, occupation and income. Evidence from previous studies also confirms that maternal educational level is a robust indicator of a child's classroom grade and standardized test scores [32], [33]. Our results conclude that maternal education alone accounted for 22.5% variance in VCI, 15.9% variance in EFSIQ and 6.6% variance in WMI. A study done by Nobel et al. in 2007 assessed neurocognitive abilities of socioeconomically diverse 150 first graders using comprehensive cognitive battery and the authors concluded that maternal education alone accounted for 27% variance in language composite and 5.7% variance in the working memory composite [12]. Furthermore, the same study demonstrated that there was no statistically significant contribution of both parents' education and occupation compared with maternal education alone. Perhaps this may be due to fact that in Asian households the mother spends more time with the children and interacts with the children from an early age thus being more involved with the tasks of parenting than the fathers. However, in line with previous studies maternal education alone significantly predicts children's cognitive and academic outcomes [34], [35], [36], [37] and findings further emphasize the importance of female education to reduce the achievement gap between low and middle SES groups.

Furthermore, the findings of this study indicate mean scores of mathematics and science were lower in female adolescents of whose parents had a low level of educational attainment compared to female adolescents of whose parents had a high level of educational attainment. In a recent neuroimaging, Noble et al. showed that parental education was linearly associated with children's total brain surface area, indicating that any increase in parental education whether an extra year of high school or college was associated with a similar increase in surface area over the course of childhood and adolescence [6]. The left perisylvian region of the brain is involved in language processing and it is susceptible to influence from environmental experiences with maturation [14]. In fact the degree of receptive language is also associated with family SES. Adolescents from low maternal education background are under exposed to rich language structure and cognitive stimulation, and therefore build vocabularies at a slower space than the children of highly educated mothers as described previously [38].

Moreover, the present study shows an inverse relationship between psychosocial adversities and cognitive indices. The psychosocial adversity scale used in the present study has been widely used in cognitive development studies in Asian countries and has shown a consistent relationship across cultures and different socioeconomic settings. Psychosocially disadvantaged adolescents are subjected to exposure by environmental, sociological and psychological stressors and subsequently this leads to adverse cognitive outcomes. Female adolescents are particularly vulnerable for stressors possibly due to the interaction between glucocorticoids and gonadal hormones. Generally cortisol levels increase in female adolescents with the onset of puberty (between 10 and 12 year of age) [39], [40] due to an elevated level of gonadal hormones (estrogen and testosterone), and persistent stress causes elevation of cortisol secretion. The elevated glucocorticoids are known to compromise cognitive processing [41], selective attention [33] and inhibitory control [42]. Advances in animal and human studies have demonstrated that exposure to stress during different stages of life affect the development of different regions of the brain [43]. More specifically the hippocampus, amygdala, frontal lobe and cortical and limbic regions undergo different development trajectories which play a key role in emotional and physiological development that accompanies adolescence. Thus, these areas are particularly sensitive for stress induced neurobehavioral dysfunctions and psychopathologies [44]. Family environment is the root for early life stress, thus any insult to psychosocial and socioeconomic wellbeing leads to detrimental effects on brain function, behavior, cognition and long lasting psychopathology [43]. These results are further substantiated by adolescents who grow up in low socioeconomic backgrounds having greater glucocorticoid levels [45]. Alternatively emerging studies indicate a sex difference in stress hormone activation. In particular female adolescents demonstrate greater stress hormone reactivity compared to boys [46]. Therefore, when all these aspects are taken together, stressful experiences in adolescence lead to greater exposure of the developing adolescent brain to steroids and other stress hormones and neurotransmittors. These insults may produce long lasting effects on the developing brain and may compromise cognitive development subsequently.

SES is a predictor of the quality of the environment the child develops and causes substantial influence for variability of intelligence through interaction of genes and environmental experiences. Turkheimer et al., in 2003, explained the magnitude of SES on the heritability IQ of young children. It demonstrated that socioeconomic disparities between the middle and upper class environment families influence the expression of genetic potential for intelligence. IQ scores of 7-year-old children for WISC-Revised were modified by the SES of children and the shared environmental influence accounted for 60% of variance in IQ of socioeconomically disadvantaged families [16]. The same findings are replicated for adolescents by another genetic study conducted by Harden et al. in 2006 [47]. The results of the present study further confirm the above results.

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Family income was not significantly accounted for variance in cognitive indices in the present study. In line with the previous literature, the negative consequences of poverty were strongly associated in preschool and early childhood years than in adolescence [34], [35], [36], [37]. Poverty in adolescence causes a relatively smaller effect on cognitive and academic achievement and years of school completion compared to the early years of life [48]. Understanding the influence of timing of poverty on adolescent wellbeing is a critical factor for policy and program makers. However, it is well documented that long lasting poverty causes a detrimental effect on cognitive and scholastic outcomes than does short-term poverty [10]. Additionally, persistent poverty in adolescence causes problematic emotional outcomes including internalizing and externalizing behavior problems [49]. Further, this impaired emotional health, in turn, may disturb cognitive skills and academic achievement.

Finally, the findings provide evidence that SES is a robust indicator of cognitive abilities. Experience influences neural plasticity and shapes the structure and function of the developing brain. SES is a construct that decides quality of physical and psychological wellbeing. The mechanism that underlies SES-related individual differences in cognitive outcomes are attributed to multiple factors, for instance, prenatal factors, postnatal care and cognitive stimulation. Being of low SES during pregnancy causes exposure to stress, impaired nutrition status and subsequently compromised fetal growth and neurodevelopment that continues into adult life [11]. Furthermore, low SES limits access to nourishing foods and leads to nutritional deficiencies. Low SES individuals also encounter stress accomplishing family and social needs, this chronic stress impairs the quality of parenting practices. Poor parenting compromises child nourishing and enrichment as well as disturbing the child's emotional and behavioral wellbeing. Less availability of a cognitively stimulating environment at home such as material wealth (books, toys, computers) and impaired parent-child interaction factors contributed to less emotional and cognitive development of low SES subjects.

Practical implications

Strategies to ameliorate cognitive skills of low SES need to be addressed through economic, health, educational and psychological aspects. Recent advances in neurocognitive research paid special attention to training specific cognitive tasks. Reforming the education curriculum with the incorporation of cognition enhances strategies in the school curricula; such as computerized cognitive training (e.g. working memory) activities benefiting nonverbal reasoning, mathematics proficiency and information processing speed of children.

Low SES led to an adverse home learning environment and parenting practices at home. Home is the root for early life stressors and it significantly influences brain development, behavior and cognition and long lasting psychopathology [50]. Parenting style plays an essential part in adolescent achievement. Low SES is often associated with neglectful parenting style, harsh punishment, violence at home and less nurturing. Absence of parent responsiveness and demand hinder parent engagement in school activities, academic motivation, psychological autonomy and the learning atmosphere [51]. An authoritative parenting style facilitates the academic stimulation of adolescents. Family centered and school centered adolescent achievement strategies involving parents and school personnel ensure its effectiveness. Thus, an effort to enhance shared responsibility between home and school primarily with low income families would optimize parents' school involvement. This can be achieved through teacher involvement as the teacher plays an important role in a child's achievement. School socioeconomic state and school quality decide the availability of resources and a stimulating environment for learning. Those children who experience a negative learning atmosphere at home and school contribute to their academic failure. It is important to conduct and train teacher awareness programs about normative behavior in dealing especially with low SES students. Furthermore, parents with low SES are likely to experience mental problems as a consequence of deep poverty. Therefore, a parent-centered program directed towards effective parenting practices, knowledge about child rearing practices, methods to cope with stressors and teaching of authoritative parenting practices would noticeably optimize the wellbeing of the child.

Limitations

All the test instructions and the subtests of the WISC were administered in the mother tongue (Sinhala). Eight subtests of the WISC were used in this study to obtain and estimate full scale IQ and other cognitive function tests such as TONI, and executive function tests were also assessed in conjunction with the WISC. The WISC has been validated for Sri Lanka and the reference norm data for the Sri Lankans closely resembles the normative data of the UK study sample. Thus, the scores of the UK-based normal population were accepted to be within the normal for the Sri Lankan adolescents and children [52]. The potential confounders on cognitive outcomes such as the level of stress, level of hemoglobin and uniformity of state of the menstrual cycle have not been accounted for in this study.

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Conclusions

Poor SES, especially poor maternal education, has a negative influence on the cognitive development of adolescent girls. This is a vicious cycle that can lead to poor education and poor SES which infiltrates into the following generations. It has to be stopped to end the vicious cycle and to enhance cognitive development. Strategies to raise the income of poor families in ways such as providing more welfare benefits, facilitating low cost adult education and better technical training are some measures that need to be essentially addressed. The investments for education from the national budget need to be increased in order to facilitate better learning. Indeed the results reflect the importance of maternal education, and its ability to empower a daughter's education is highlighted. Well-educated mothers are essentially needed to breakdown the vicious intergenerational transmission of poor cognitive development being intertwined with the socioeconomic cycle.

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Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contribution: HJM was involved in designing the study, collection of data, preparing the data base, statistical analysis of data, interpretation of data and writing the first draft of the manuscript. SWW was involved in designing the study, critical analysis of results, interpretation of data, manuscript writing and final proof reading before submission. CSEG was involved in designing the study, interpretation of data, manuscript writing and final proof reading before submission. AATDA was involved in designing the study, interpretation of data, manuscript writing and final proof reading before submission. JL was involved in designing the study, interpretation of data, critical analysis of results, manuscript writing, final proof reading before submission and supervision of progress of the study.

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