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Nutritional Status and Its Association with Cognitive Function among School Aged Children at Soddo Town and Soddo Zuriya District, Southern Ethiopia: Institution Based Comparative Study

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Abstract

About 1 billion stunted school-aged children are growing up with impaired mental development which can lead to low cognitive performance, reduced school achievement, and low productivity. But there is scarce evidence on cognitive function, school performance and their associated factors among school aged children. The main aim of this study was to assess cognitive function, school performance and determine their association with nutritional status among school children aged 7 to 10 years at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia. Institutional comparative cross-sectional study was conducted on a total sample of 178 primary school children. The Raven's Color Progressive Matrices (RCPM) and selected tests from Kaufman assessment battery for children second edition were used. Mid-year average students' examination result was also used. Data were analyzed by using SPSS version 25, WHO Anthro plus, and independent sample *t*-test. Bivariate and multivariate linear regression analyses were also used. Mean (±SD) cognitive test scores of urban study participants was 18.7 ± 3.4 for RCPM which was higher ($P < .001$) as compared to rural (16.5 ± 3.3). The urban mean cognitive test scores was also higher for both pattern reasoning and visual processing with ($P < .001$) as compared to rural counterparts. School performance was higher ($P < .001$) for urban. Maternal education ($P < .002$) and wealth index ($P < .006$) were positively predicted while stunting ($P < .001$) negatively predicted cognitive function test scores and school performance. Cognitive function and school performance of study participants were associated with their nutritional status and rural participants had significantly lower mean scores as compared to urban counterparts. Further study should be done to community level.

Keywords

cognitive function, school children, school performance, rural, urban

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Introduction

Optimal nutrition during childhood is necessary for normal brain development of children since it is an important period for the formation of the brain, laying the foundation for the development of cognitive, motor, and socio-emotional skills throughout their life.[1] On the other hand poor nutrition during early period can result in a long lasting physical and mental impairment by affecting the structural and functional development of the brain.[2]

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Globally, there were more than 200 million stunted school age children. If action is not taken, there are about 1 billion school age children growing up with impaired physical and mental development mainly due to poor nutrition and poor socio-economic status.[1,8] Consequently the performance of children, who had earlier suffered from malnutrition, was clearly inferior to that of children who had not gone through malnutrition, which results in inferior school performance, early school dropout, low skilled employment, and productivity.[4,5]

In developing countries like Ethiopia, millions of school children suffer from nutritional deficiencies and frequent infections which can have a negative effect on their physical, cognitive, and behavioral development.[6] This is mainly due to poor nutrition, poor socio-economic status, less stimulating environment, lack of access to basic water and sanitation, and lack of access to quality health services.[1,22] According to Ethiopian mini demographic and health survey 2019, Ethiopia has one of the highest rates of chronic malnutrition (37%) in the world. It is evident that chronic under nutrition in early years was significantly associated with poor cognitive performance at school and adult life. Chronic under nutrition has also an immense impact on the productivity of individuals. Stunted children grow up to become less productive adults and labor productivity declines by 1.4% for every 1% loss in adult height. Adults affected by under-nutrition in childhood earn almost 20% less than their non-affected counterparts and also under-nutrition can lead to an annual gross domestic product (GDP) loss of 2% to 3% which implies that it has a devastating effect on overall economic development of countries.[7,8]

The burdens of under nutrition and poor mental function on school aged children are also the major constraints in achieving sustainable development goals. Though there are well established documents on the magnitude of under 5 malnutrition in Ethiopia, there is a lack of evidences which reveal the effect of nutritional status on cognitive function of school children. Determining nutritional status and cognitive function of school children which directly or indirectly affects the future productivity of children and economic growth of the countries as a whole is crucial in order to take measures to tackle the problems. The main aim of this study was to assess cognitive function, school performance and determine their association with nutritional status among school children aged 7 to 10 years at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia.

Methods

Study Setting and Period

This study was conducted in urban and rural governmental primary schools in Soddo Town and Soddo Zuriya Woreda of Wolaita Zone, Southern Ethiopia. Wolaita Zone is 1 of the 14 zones in the Southern Nations Nationalities and Peoples Region (SNNPR). The area is 330 km south from Addis Ababa and 160 km away from the regional town, Hawassa. The Altitude of the study area is 1501 to 3000 m above sea level with annual rain fall of 169.5 cm. There are 2 referral hospitals, 3 health centers, and 28 high and medium private clinics at Soddo town, and there were 7 health centers, 41 health posts, and 18 medium private clinics at Soddo Zuriya Woreda. Common staple foods in the area are cereals, roots, tubers, and vegetables (Wolaita Zone Health Department Annual report). Similar to other parts of the country the formal educational system of the study area has 2 cyclic systems, the first cycle which holds grades 1 to 4 and the second cycle which comprises grades 5 up to 8. Total number of governmental primary schools in Soddo town and Soddo Zuriya Woreda are 10 and 31 respectively. All the schools at Soddo town are with both cycles and 22 schools at Soddo Zuriya Woreda are with both cycles (1-8) and the rest 9 were with first cycles (1-4). Total enrollment in primary school children at Soddo town and Soddo Zuriya Woreda are 12 945 and 41 363 respectively (source: Soddo town administration education office and Soddo Zuriya Woreda education office Annual report).

Study Design and Period

An institution/school/based comparative cross-sectional study was employed from February 25 to April 15, 2014.

Source Population

All governmental primary school children aged 7 to 10 years at Soddo town and Soddo Zuriya Woreda.

Study Population

Selected school children aged 7 to 10 in 5 selected primary schools at Soddo town and Soddo Zuriya Woreda.

Inclusion Criteria

Primary school children aged 7 to 10 years who are permanent residents in the study area for at least 6 months were included in the study.

Exclusion Criteria

Children who had health problems (like visual impairment, hearing impairment, and mental problems, which are expected to affect their cognitive performance) and who recently came (less than 6 months) from rural to urban area for schooling.

Sample Size Determination and Sampling Procedure

Sample Size Determination

Sample size was done for the first and second specific objectives and the largest sample size was used for this study. Sample size for the first objective was determined by using G power statistical software version 3.1.5 (27) with the assumptions: taking the mean difference of cognitive function between 2 groups as 0.5 (medium effect size), the level of significance (α), .05 ($Z\alpha/_2 = 1.96$), and the power efficiency (1 − ß) 100% is 80%. The software gives total sample size of 128 for 2 independent groups. Considering 5% non-response rate, the total sample size for 2 groups was (n = 134), which is the minimum sample size needed to detect a mean difference in cognitive performance of urban and rural school children in the study area. Equal number of study participants ($n_1 = n_2 = 67$) was supposed to be taken from urban and rural primary schools for the study.

Sample size for the third objective was estimated by using single population proportion formula. The prevalence of stunting among school children was taken as 12.9% which was taken from the study done at Hawassa town (24). Therefore this prevalence was used to calculate the sample size with the following assumptions, Level of significance to be 5% (α = 0.05), $Z\alpha/_2 = 1.96$, and absolute precision or margin of error to be 5%.

$$n = \frac{(Z\alpha/2)^2 P(1-P)}{d^2}$$

Where n = calculated sample size
P = prevalence of stunting among school children (12.9%)
Z = standard normal variable at 95% confidence level (1.96).
d = the margin of error or accepted error (0.05)

$$n = \frac{(1.96)^2\, 0.219(1-0.219)}{(0.05)^2} = 172$$

After 5% contingency for the non-responses, the final sample size was 180. The same procedure was also done by using stunting prevalence of 11% among rural school children at Angolela, Ethiopia (25). But it gives smaller sample size when calculated ($N_{total} = 158$) as compared to the one which is done for urban. Since the urban one gives the largest sample size ($N_{total} = 180$), it was used for this study and equal number of study participants ($n_1 = n_2 = 90$) was taken from urban and rural primary schools for the study.

Sampling Procedure

In the first stage, a separate list 10 of urban and 31 rural primary schools (governmental schools) existing in Soddo town and rural areas of Soddo Zuriya Woreda were obtained. Then 5 schools (2 from urban and 3 from rural) were selected randomly from their respective totals. The total sample size was assigned equally to urban and rural area being 90 samples for each. Then, the number of children to be selected from each school was determined by using proportional to size allocation as follow;

$$ni = \left(\frac{N_i}{N}\right) \times n$$

Where; n_i = the sample size of the ith school
N_i = the population size of the *i*th school
n = the total sample size for each area (90)
N = the total population size for 2 urban and 3 rural schools.
} for each school

Then after, a sampling frame was prepared for each school by listing all of students aged 7 to 10 years and finally, in the second stage, the determined number of children from each school was selected by using simple random sampling generated using excel (Figure 1).

Data Collection Process

Socio-Demographic and Economic Data

A pre-tested structured questionnaire was used to collect socio-demographic and other relevant child and household information by using interview method. Parents were requested to come to school for interview. If parents were unable to come to school, data collectors went to their home with the students to conduct the interview. Information on household assets and access variables was used to create an index representing the wealth of the household. A wealth category composed of 16 variables was formed to assess socioeconomic status and to make comparisons between study participants. The variables used to assess wealth in 2011 Ethiopian Demographic and Health survey (28) and variables suggested for use in classifying wealth in urban and rural Ethiopian households (29) were used to construct the wealth categories for both urban and rural areas. Categorical variables used were transformed into dichotomous indicators. These indicators and those that are continuous are then examined using a principal components analysis (PCA) to produce a common

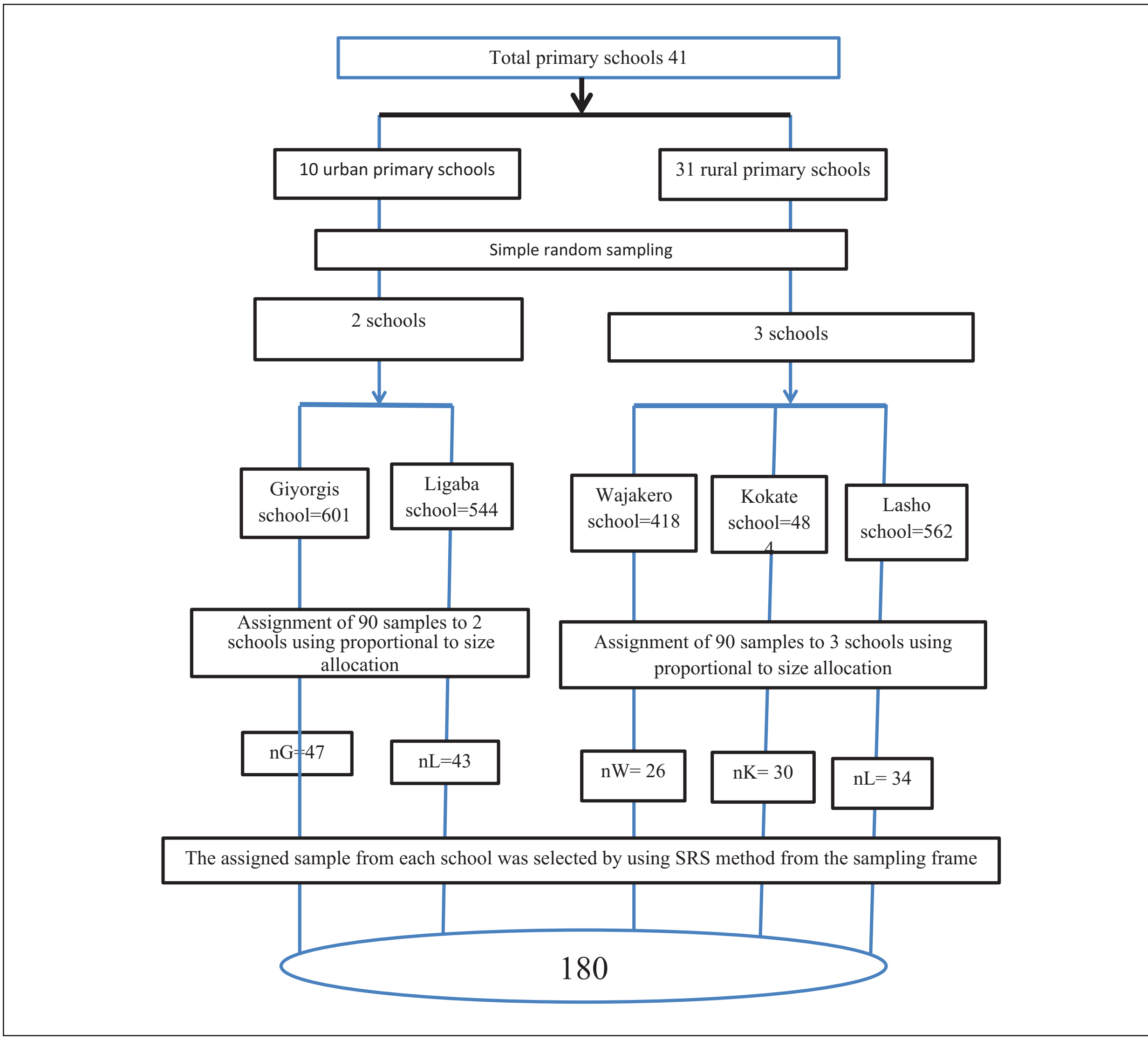

Figure 1. Flow chart of the sampling procedures of study participants from urban and rural selected schools of Soddo Town and Soddo Zuriya Woreda Wolaita Zone, Southern Ethiopia, April 2014.

factor score for each household. Separate factor scores were produced for households in urban and rural areas using area-specific indicators and variables with smaller Eigen values were excluded from the list both for urban and rural households. Then the area specific factor scores were combined to produce a common wealth index by adjusting area specific factor scores. The variables that were used in wealth construction include asset ownership, house type, type of toilet facility, number of rooms for sleeping, presence of windows, type of flooring, separate room for cooking (barn), and source of drinking water according to the EDHS format. Each categorical variable was given a weighted numerical value in which higher values assigned to 1 and lower values assigned to 0.

Measurement

Dietary Assessment

Dietary intake was assessed by 24 hour recall method and child diet diversity was constructed based on 8 food groups. A child considered as having good dietary diversity when a child ate 4 and above food groups while a child dietary diversity considered as poor when a child ate 3 and below 3 food groups.[9]

Anthropometric Data

The height of the child was measured to the nearest 0.1 cm using the Short measuring board without shoes in a standing position. Body weight was recorded to the nearest 0.1 kg using the UNICEF SECA weighing scale. Instruments were checked against a standard weight for accuracy daily. Calibration of the indicator against 0 reading was checked following weighing every child and all children weighed with light clothing and without shoes. Both measurements were taken in duplicate. The age of the child in complete years was obtained from school lists and confirmed with parents.

Cognitive Function Testing

The cognitive function of the students was assessed by using the Raven's colored progressive matrices (board version) and Selected tests from the Kaufman Assessment Battery for Children (KABC-II). From KABC-II tests Number Recall and Word Order which measure sequential processing (short term memory) were used. The maximum scores for these tests are 22 and 31 respectively. For measuring simultaneous processing (visual processing) the Rover and Triangles were used. The maximum score for these tests are 44 and 29 respectively. Planning (fluid reasoning) was measured by using Pattern Reasoning. The maximum score for the test is 36. Tests measuring learning and knowledge did not used for this study because they were not used previously in similar cultural settings. Core subsets for planning and conceptual thinking were not administered because; in previous study done in similar settings, most of the pictures in the subsets were not familiar to the child.[10] Raven's Colored Progressive Matrices (RCPM) made up of 3 sets of 12 problems which measures the ability to solve problems and reasoning by analogy and has been used extensively as a culturally fair test of intelligence.[11]

School Performance

The midyear total academic score rated out of 100 was used to estimate school performance of children included in this study and was taken from school records.

Data Quality Management

To ensure data quality, degree holder data collectors who can speak both the Amharic and local language (wolaitegna) fluently were deployed. A 5-day intensive training was given for data collectors on cognitive assessment tools, anthropometric measurements, and socio-demographic and economic characteristics by principal investigator (PI). A pre-test was done on 6 children in one of the schools in urban area which is not part of the study. After pre-test, discussions were made with data collectors to clear any confusion about each assessment tools, to estimate time needed and corrective measures were taken. The questionnaire was modified and contextualized to the local situation and the research objective. The questionnaire first prepared in English and then translated into Amharic and back to English by another person to check for consistency. Six data collectors were recruited in the study including principal investigator and 1 person assessed a single cognitive test throughout the study. Cognitive performance assessment was carried out in 2 free rooms in each school. All anthropometric measurements were taken by PI and Calibrated data collection instruments prior to each measurement were used. The collected data were reviewed and checked for completeness and consistency every day. Any confusion during data collection was communicated and corrective measures were taken immediately before proceeding the next day. The principal investigator monitored overall activities.

Data Processing and Analysis

The data were entered and checked for errors using epidata entry 3.02, and analyzed using SPSS. Anthropometric indices WAZ, HAZ, and BAZ were calculated by using WHO Anthro plus version 1.0.1. Children with Z-scores less than −2 standard deviation values for WAZ, HAZ, and BAZ were classified as underweight, stunted, and wasted respectively.[12] Descriptive statistics were used to analyze means, standard deviations, and frequency of continuous and categorical variables. Mean cognitive test scores and school achievement between urban and rural study participants, stunted and normal, and underweight and normal children were compared using independent 2 sample t-test. Wealth index was constructed by using PCA. Bivariate and multivariate linear regression was used to identify predictors of cognitive performance and school achievement and only variables that were significantly associated at $P < .02$ in bivariate linear regression analyses were entered in the multivariable linear regression model. At this step, co-llinearity diagnostics was done by checking the variance inflation factor. Normality of the continuous variables was checked visually using Q-Q plots, P-P plot, and scatter plot of residuals against the predicted values and using the Kolmogrov–Smirnov test. Correlations were evaluated using Pearson's coefficients. All tests were 2-sided and $P < .05$ was considered statistically significant. Values were given as means and standard deviations, and minimum and maximum scores of cognitive tests and school performance were also reported as appropriate.

Table 1. Characteristics of Study Subjects by Residential Area at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014.

Characteristics				Grade attended (%)	Pre-school
Setting	Age (years)	Sex ratio (M/F)	Grade 1	Grade 2 and above	Attendance (%)
Urban	8.7 ± 1.0a	1.4	64.4	35.6	77.8
Rural	8.8 ± 1.0	1.1	60.2	49.8	34.9
Total	8.8 ± 1.0	1.2	59.6	40.4	56.2

[a]X ± SD (for all such values), M/F: Male to Female ratio.

Operational Definition

School age: Children in the age group of 5 to 14 years are often considered as school-age.

Cognition: High level physiological processes involved in perception, attention, memory, language, problem solving, reasoning, and making decisions.

Cognitive development: The construction of thought processes, including remembering, problem solving, and decision-making beginning in infancy and continuing to change or progressively improve through adolescence and adulthood.

Cognitive function: Person's capacity to acquire and use information to adapt to environmental demands; the process involves many skills including attention, creativity, memory, perception, problem solving, thinking, and the use of language. In this study, it is an expression of a desired result according to a specific cognitive function tests conducted.

Cognitive performance: An expression of a desired result of a learning experience according to specific cognitive tests conducted (26).

School achievement: The progress of individuals in school measured by the results ofexaminations. In this study, the first semester (2013/14 academic year) average test results of all subjects that the student performed were taken from the records of each their respective school.

Results

Characteristics of Study Participants

A total of 178 students were enrolled in this study, urban 90 and rural 88, with a response rate of 100% and 98%, 2 children were absent from the rural group. The mean (±SD) age of study participants were 8.7 ± 1.0 and 8.8 ± 1.0 for urban and rural study groups respectively. From the total of 178 students, 98 (55.1%) were males and 80 (44.9%) were females. Male to female ratios were 1.4 and 1.1 for urban and rural study participants. There was no statistically significant difference on mean age (t = −0.707, P = .481) and sex (X^2 = 1.081, P = .299) distributions between urban and rural study participants. The majority of study participants were grade 1 for both urban (64.4%) and rural (60%) areas. About 77.8% and 34.9% of urban and rural study participants had attended pre-school. Years of pre-school attendance by children ranged from 1 to 4 years with median value of 2 (Table 1).

Socio-Demographic Characteristics of the Respondents

The majority of respondents were from Wolaita ethnic group (91%) and the rest 3.4% and 2.8% were Amhara and Gurage by ethnicity, and the remaining were Tigre (1.7%) and others (1.1%). Almost half (52.2%) of the families of study participants were protestant by religion followed by Orthodox Christians (34.8%) and the rest were Muslims which accounted for 10%. About 48.9% and 55.7% of urban and rural households of study participants were husband headed and the remaining 34.4% and 36.4% of urban and rural households were headed by both parents (father and mother). The mean (±SD) family size in this study was 5.3 ± 2.0 and 6.9 ± 2.4 for urban and rural study participants. Most of families in this study had a family size of (≥6) for both urban (42.2%) and rural (61.4%) study participants respectively. Regarding educational status, the proportion of parents with college and above education was 32.1% and 25.6% for urban fathers and mothers but it was only 3.7% and 2.3% for rural fathers and mothers. Conversely the proportion of parents with no formal education was higher among rural fathers (35.4%) and mothers (51.7%) than urban fathers (19.2%) and mothers (26.7%). About 35.9% and 24.4% of fathers and mothers from urban respondents were government employed but most of the fathers (81.7%) and mothers (74.7%) from rural respondents were farmers and housewives by occupation (Table 2).

Household Characteristics of Study Participants

The majority of the urban (80%) and rural (42%) households were using piped water as their source of drinking water. The rest 14.4% and 44.3% of urban and rural

Table 2. Socio-Demographic Characteristics of the Respondents at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014.

Characteristics	Urban (n = 90) (%)	Rural (n = 88) (%)	N = 178 (%)
Religion			
Protestant	47 (52.2)	59(67.0)	106(59.6)
Orthodox	34 (37.8)	28(31.8)	62(34.8)
Muslim	9 (10.0)	0	9(5.0)
Catholic	0	1(1.1)	1(0.6)
Marital status of parents			
Married	78(86.7)	81(92)	159(89.3)
Divorced	7(7.8)	0	7(3.9)
Widowed	4(4.4)	5(5.7)	9(5.1)
Separated	1(1.1)	2(2.3)	3(1.9)
Head of household			
Father	44(48.9)	49(55.7)	93(52.2)
Mother	15(16.7)	7(8.0)	22(12.4)
Both	31(34.4)	32(36.4)	63(35.4)
Mean(±)family size	5.3 ± 2.0	6.9 ± 2.4	6.1 ± 2.4
Fathers education			
No formal education	15(19.2)	29(35.4)	44(27.5)
1-4 class	11(14.1)	23(28)	34(21.2)
5-8 class	12(15.4)	20(24.4)	32(20.0)
9-12 class	15(19.2)	7(8.5)	22(13.8)
College and above	25(32.1)	3(3.7)	28(17.5)
Mothers education			
No formal education	24(26.7)	45(51.7)	69(39.0)
1-4 class	16(17.8)	26(29.9)	42(23.7)
5-8 class	14(15.6)	11(12.6)	25(14.1)
9-12 class	13(14.4)	3(3.5)	16(9.0)
College and above	23(25.5)	2(2.3)	25(14.1)
Fathers occupation			
Farmer	0	67(81.7)	67(41.9)
Gov't employ	28(35.9)	4(4.9)	32(20)
NGO employ	2(2.6)	0	2(1.2)
Merchant	23(29.5)	5(6.1)	28(17.5)
Daily laborer	21(26.9)	4(4.9)	25(15.6)
Others	4(5.1)	2(2.4)	6(3.8)
Mothers occupation			
Housewives	25(27.8)	65(74.7)	90(50.8)
Gov't employ	22(24.4)	2(2.3)	24(13.6)
Merchant	27(30)	15(17.3)	42(23.7)
Daily laborer	14(15.6)	5(5.7)	19(10.7)
Others	2(2.2)	0	2(1.1)

households were using protected/well/spring/water as their source of drinking water. About 92.2% and 53.4% of urban and rural families were living in corrugated iron roof and grass roof houses. Most of the urban (87.8%) and about half of the rural (48.9%) households had windows. Almost all of the rural houses floor material was soil/mud/ (95.5%) but about half of the urban houses floor material was cement (53.3%). Most of urban (74.4%) and rural (48.9%) respondents had latrines with slab and houses. About 13.3% and 23.8% of the urban and rural respondents had pit latrine without slab and the rest 7.8% and 21.6% of the urban and rural respondents had latrine with slab. Six percent of rural households had no latrine. More than half (62.9%) of the respondents had personal latrine and the rest 37.1% had shared latrine. About 91.1%, 75.6%, 58.8%, 30%, and of urban respondents had mobile phone, radio, TV, and bicycle while almost none of the rural respondents had TV and bicycle and 42% of them had radio (Table 3).

Table 3. Household Characteristics of Study Participants at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014.

	No. (%)		
Characteristics	Urban (n = 90)	Rural (n = 88)	Total (N = 178)
Source of drinking water			
Household (public) tap	72 (80)	37 (42)	109 (61.2)
Protected well/spring	13 (14.4)	38 (43.2)	51 (28.7)
Unprotected well/spring	5 (5.6)	7 (7.9)	12 (6.7)
River/Dam	0	6 (6.8)	6 (3.4)
Main material for the roof			
Grass roof	0	47 (53.4)	47 (26.4)
Corrugated iron roof	83 (92.2)	41 (46.6)	124 (69.7)
Cement walls and iron roof	7 (7.8)	0	7 (3.9)
Presence of windows			
No	11 (12.2)	45 (51.1)	56 (31.5)
Yes	79 (87.8)	43 (48.9)	122 (68.5)
Main material for the floor			
Soil/mud	42 (46.7)	84 (95.5)	126 (70.8)
Cement	48 (53.3)	4 (4.5)	52 (29.2)
Number of rooms for sleeping			
One	33 (36.7)	59 (67)	92 (59.7)
Two and above	57 (63.3)	29 (33)	86 (48.3)
Separate room used for cooking (Barn)			
No	23 (25.6)	72 (81.8)	95 (53.4)
Yes	67 (74.4)	16 (18.2)	83 (46.6)
Latrine facility			
No latrine	0	5 (5.7)	5 (2.8)
Pit latrine without slab	12 (13.3)	21 (23.8)	33 (18.5)
Pit latrine with slab	7 (7.8)	19 (21.6)	26 (14.6)
Latrine with slab and house	67 (74.4)	43 (48.9)	110 (61.8)
[a]VIP latrine	3 (3.3)	0	3 (1.7)
Flush toilet	1 (1.1)	0	1 (0.6)
Household possessions			
Radio	68 (75.6)	37 (42)	105 (59)
[b]TV	53 (58.9)	1 (1.1)	54 (30.3)
Electricity	90 (100)	12 (13.6)	102 (57.3)
Bicycle (motor/car)	27 (30)	1 (1.1)	28 (15.7)
Mobile phone	82 (91.1)	43 (48.9)	125 (70.2)
Land size in hectares			
≤0.5 hectares	2 (2.2)	38 (43.2)	40 (43.0)
0.51-1.0 hectares	3 (3.3)	35 (39.8)	38 (40.9)
>1.0 hectares	0	15 (17.0)	15 (16.1)
Number of farm animals			
Two and less	6 (6.7)	22 (26.5)	28 (30.8)
More than 2 animals	2 (2.2)	61 (73.5)	63 (69.2)

[a]Ventilated improved pit latrine.
[b]Television.

Dietary Pattern of School Age Children

Almost all of the study participants, (96.7% of urban and 100% rural) consumed foods made from grains, roots and tubers. But only 12.2% and 5.7% of urban and rural study participants consumed meat, poultry, and fish. About half (52.2%) of the study participants consumed Vitamin A rich fruits and vegetables. The mean (±SD) diet diversity for the study groups was 3.5 ± 0.9, with means being higher for urban study participants (3.7 ± 0.9) (t=2.51; P=.013) as compared to rural counterparts (3.4 ± 0.8) respectively (Figure 2).

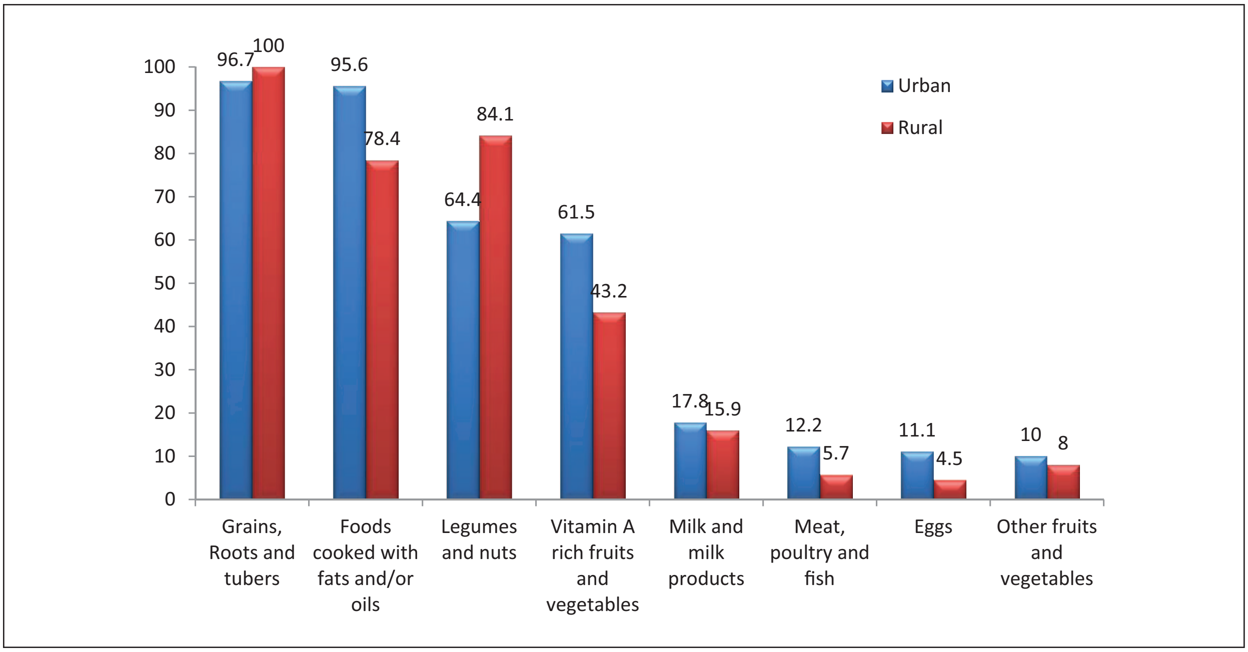

Figure 2. Percentage of study participants consuming food groups in urban and rural areas, Wolaita Zone, Southern Ethiopia, April 2014.

- Grains (food made with maize, barley, teff, and wheat)
- Roots and tubers (potatoes, sweet potato, false potatoes [kocho])
- Legumes and nuts (kidney beans, haricot beans cowpeas, chickpeas, and any mixed dish prepared of beans)
- Vitamin A rich fruits and vegetables (ripe banana, avocado, mangos, papayas, pumpkin, carrots, yellow/orange fleshed sweat potatoes)
- Other fruits and vegetables (any dark green leafy vegetables; pumpkin leaves, kale any dark green leaves).

Anthropometric Status of Study Participants

About 11.2% and 16.3% of children were underweight (weight-for-age <−2SD) and stunted (height-for-age <−2SD). Six percent of children were wasted (BMI-for-age <−2SD).

Prevalence of stunting and underweight was 13.3% and 10% in urban and 19.3% and 12.6% in rural study participants respectively. The mean (±SD) scores for WAZ, HAZ, and BMZ for urban and rural children were −0.88 (0.79), −0.76 (0.97), −0.63 (0.81) and −0.94 (0.74), −0.84 (1.0), −0.67 (0.81) respectively (Table 4).

Cognitive Function Test Scores and School Performance of Study Participants

The mean (±SD) cognitive performance test score of study participants was 17.6 ± 3.5 out of the possible 36 scores for RCPM, 7.3 ± 3.5 out of the possible 44 scores for pattern reasoning, 24.3 ± 4.8 out of the possible 53 scores for sequential processing, and 23.3 ± 5.4 out of the possible 73 scores for simultaneous processing. The mean (±SD) school performance of study participants was 70.0 ± 8.7 out of 100. Table 5 presents mean, minimum, and maximum test scores for each sub test and the maximum value that could be attained for each test administered.

Comparison of Cognitive Function Tests Scores and School Performance of Urban and Rural Study Participants

The higher scores for all cognitive tests indicate better performance, and in most of cognitive tests study participants from the rural area performed relatively lower than their urban counterparts ($P < .05$). The mean (±SD) cognitive performance test score for urban study participants was 18.7 ± 3.4 for RCPM which is higher ($P < .001$) as compared to rural which was 16.5 ± 3.3. For KABC-II tests, the mean test scores of the urban study participants was also higher for Triangles ($P < .018$), Rover ($P < .013$), Pattern Reasoning ($P < .001$), and simultaneous processing ($P < .001$) when compared to the rural participants. But the difference was not significant for Word Order ($P < .138$), Number Recall ($P < .215$), and sequential processing ($P < .312$). School performance of the urban study participants was also higher ($P < .014$) with mean (±SD) value of 69.5 ± 9.3 as compared to the rural counterparts (66.6 ± 7.8) (Table 6).

Table 4. Anthropometric Status of Study Participants at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014.

	Urban (n = 90)		Rural (n = 88)		Total (N = 178)	
Indices	No.	%	No.	%	No.	%
Weight-for-age *Z* score						
Normal	81	90	77	87.5	158	88.8
Underweight	9	10	11	12.6	20	11.2
Height-for-age *Z* score						
Normal	78	86.7	71	80.7	149	83.7
Stunted	12	13.3	17	19.3	29	16.3
BMI-for-age *Z* score						
Normal	85	94.4	82	93.2	167	93.8
Wasted	5	5.6	6	6.8	11	6.2

Table 5. Cognitive Function Test Scores and School Performance of Study Participants at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014 (n = 178).

Tests	Mean (±SD)	[a]Min. score	[b]Max. score	[c]Maximum value
RCPM[d]	17.6 ± 3.5	8	28	36
Triangles	13.2 ± 2.6	7	25	29
Word order	13.7 ± 2.9	9	28	31
Pattern reasoning	7.3 ± 3.5	2	18	44
Rover	10.1 ± 3.5	4	19	22
Number recall	11.3 ± 2.6	6	18	36
[e]Sequential scale	24.3 ± 4.8	16	46	53
[f]Simultaneous scale	23.3 ± 5.4	11	43	73
School performance	70.0 ± 8.7	48	94	100

[a]Minimum test score.
[b]Maximum test score.
[c]The maximum value that could be attained for a test administered.
[d]Raven's colored progressive matrices.
[e]Number recall + word order.
[f]Triangles + Rover.

Table 6. Comparison of Cognitive Function Test Scores and School Performance of Urban and Rural Study Participants at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014 (n = 178).

	Mean (±SD)		
Tests	Urban (n = 90) (95% CI)	Rural (n = 88) (95% CI)	[d]*P* value
RCPM[a]	18.7 ± 3.4	16.5 ± 3.3	.001*
Triangles	13.9 ± 2.7	12.4 ± 2.2	.018*
Word order	13.8 ± 3.4	13.6 ± 2.2	.138
Rover	10.9 ± 3.0	9.2 ± 3.8	.013*
Number recall	11.1 ± 2.8	11.4 ± 2.4	.215
Pattern reasoning	8.8 ± 3.5	5.9 ± 2.8	.001*
Sequential scale[b]	24.9 ± 5.6	24.7 ± 4.2	.312
Simultaneous scale[c]	24.9 ± 5.1	21.6 ± 5.2	.001*
School performance	69.5 ± 9.3	66.6 ± 7.8	.014*

[a]Raven's colored progressive matrices.
[b]Number recall + word order.
[c]Triangles + Rover.
[d]Independent 2 sample *t*-test.
*Statistically significant difference observed at $P < .025$ (2-tailed).

Table 7. Pearson's Correlation Coefficients for Cognitive Tests.

		RCPM	Tri.	WO	PR	Rov.	NR	Seq.	Simu.
1	RCPM[a]	1							
2	Tri.[b]	.49*	1						
3	WO[c]	.51*	.55*	1					
4	PR[d]	.43*	.48*	.48*	1				
5	Rov.[e]	.47*	.58*	.50*	.47**	1			
6	NR[f]	.46*	.40*	.62*	.43*	.48*	1		
7	Seq.[g]	.52*	.52*	.85*	.53*	.50*	.74*	1	
8	Sim.[h]	.48*	.78*	.55*	.49*	.83*	.46*	.64*	1

[a]Raven's colored progressive matrices.
[b]Triangles.
[c]Word order.
[d]Pattern reasoning.
[e]Rovers.
[f]Number recall.
[g]Sequential processing.
[h]Simultaneous processing.
*Correlations were significant at the .01 level.

Correlation between cognitive test scores was strongly positive and this positive correlation was significant for all tests ($P < .01$). Raven's CPM test also positively correlated with all of the KABC-II tests (Table 7).

Association Between Anthropometric Status, Cognitive Function, and School Performance of Study Participants

Comparison of study participant's cognitive test scores and school achievement by their anthropometric status showed that children who were stunted (height-for-age <-2) and underweight (weight-for-age <-2) generally had lower mean cognitive test scores and school achievement than those who were normal. The difference was significant for all cognitive test scores and school performance ($P < .05$) except Pattern Reasoning ($P = .16$) and the simultaneous scale ($P = .22$) in underweight and normal children (Table 8).

Socio-Demographic Factors Associated with Cognitive Function and School Achievement of Study Participants

Variables that were individually predicted ($P < .02$) cognitive function test scores and school performance of children were entered in the multivariable regression model. Stepwise regression analysis was used and only significant values were reported. Wealth index ($P < .006$) and height-for-age Z score ($P < .001$) significantly predicted RCPM, pattern reasoning (planning ability), and school achievement after controlling for other variables. Maternal education ($P < .002$) and child diet diversity ($P < .005$) were also highly predictive for both sequential processing (short term memory) and simultaneous processing (visual processing) the model explaining 22.2% and 35.6% of variation respectively after controlling for other confounder variables. Maternal education ($P < .011$) also significantly contributed to prediction of school performance of children after controlling for other potential confounders. Cognitive performance test scores of children used as independent predictors of school achievement and pattern reasoning ($P < .004$) and RCPM ($P < .001$) were positively predicted school achievement of study participants. Years of pre-school education ($P < .003$) positively contributed to prediction of both Raven's test and school achievement of children (Table 9). Height-for-age Z score negatively predicted cognitive function and school achievement of children indicating that a unit increase in stunting showed a significant decrease in most of cognitive performance tests and school achievement. Wealth index and maternal education positively predicted cognitive function school achievement of study participants implying that each unit increase in wealth index and years of maternal schooling showed a significant increment on sequential and simultaneous processing tests and school achievements.

Discussion

The results of our study found that study participants from urban schools had higher mean scores than their rural counter parts in Raven's colored progressive

Table 8. Cognitive Function and School Achievement of Study Participants by Their Anthropometric Status at Soddo Town and Soddo Zuriya Woreda, Wolaita Zone, Southern Ethiopia, April 2014.

	Cognitive tests				
	[a]RCPM	[b]PR	[c]Sequ. sc.	[d]Simu. sc.	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	[e]School performance
[f]HAZ score					
2 (n = 149)	18.3 ± 3.3[e]	7.7 ± 3.5	25.1 ± 4.8	24.2 ± 5.3	69.9 ± 8.1
<−2 (n = 29)	13.9 ± 2.0	5.5 ± 2.4	20.3 ± 2.5	18.7 ± 3.5	58.6 ± 5.0
[g]*P* value	0.001*	0.002*	0.015*	0.001*	0.001*
[h]WAZ score					
≥2 (n = 149)	17.9 ± 3.4	7.5 ± 3.6	24.5 ± 4.8	23.5 ± 5.5	68.8 ± 8.8
<−2 (n = 20)	15.2 ± 3.5	6.3 ± 2.6	23.1 ± 4.8	21.3 ± 4.3	62.2 ± 5.0
P value	0.001*	0.16	0.017*	0.22	0.008*
BAZ score					
≥2 (n = 167)	17.5 ± 3.3	7.4 ± 3.5	25.1 ± 4.5	23.4 ± 5.4	68.5 ± 8.8
<−2 (n = 11)	18.4 ± 3.4	6.7 ± 2.8	23.9 ± 3.4	21.7 ± 4.5	65.8 ± 5.1
P value	0.451	0.481	0.14	0.111	0.103

[a]Raven's colored progressive matrices.
[b]Pattern reasoning.
[c]Sequential scale.
[d]Simultaneous scale.
[e]Mean ± SD all such values.
[f]Height-for-age z score.
[g]independent *t*-test.
[h]Weight-for-age z score.
*Differences are significant at $P < .05$.

matrices, Pattern Reasoning, and Simultaneous scale cognitive test scores. However the difference was not statistically significant for sequential processing cognitive test scores such as Number Recall and Word Order. A similar study which assessed cognitive development of urban and rural African school children also revealed that the cognitive development of urban school children was higher compared with the rural school children.[15] A cross-sectional study done in Nigeria also showed that urban children performed significantly better than their rural counterparts in all cognitive performance tests.[16] Another study from Peru reported that children residing in urban areas had improved cognitive development than children residing in rural areas.[17] Many studies showed that socio-economic background, poor parental interaction, unstimulating home and school environment, and skills of teachers affects cognitive development of children and could also be possible explanation for differences in cognitive function of study participants from urban and rural settings in this study.[3,13,14]

This study also showed that about 16.3% and 11.2% of children were stunted and underweight and they were associated with cognitive test scores. Stunted (HAZ <−2SD) and underweight (WAZ <−2SD) children had significantly lower mean cognitive test scores as compared to those who were normal. The Raven's colored progressive matrices (RCPM) was significantly lower in stunted children as compared to normal children and significantly lower scores were also observed for planning ability, short term memory, and for visual processing in stunted children as compared to normal children. Underweight children had also significantly lower mean cognitive test scores for RCPM and the scale measuring short term memory. This implies that poor nutrition significantly affected both physical and cognitive development of school children in the area. This finding is consistent with other studies done in many developing countries.[18,19] A similar finding from Malaysia which assessed the effect of gender and nutritional status on academic achievement and cognitive function among primary school children reported that stunting was negatively associated with cognitive function.[20] A cross-sectional study from India reported that under nutrition was also negatively associated with poor psychological tests among school children.[21] A follow-up study which assessed the determinants of cognitive function in childhood in Brazil also reported that stunting and underweight were negatively associated with cognitive function test scores.[22]

Table 9. Stepwise Regression Showing Predictors of Cognitive Function and School Achievement of Study Participants at Wolaita Zone, Southern Ethiopia, April 2014.

Variables	Beta	SE	*P* value
RCPM[a]			
[∅]HAZ score	3.41	0.63	.001
Years of pre-school attendance	1.45	0.46	.002
Wealth status	0.91	0.26	.006
*Residential area	1.75	0.71	.015
Adj. R^2	0.322		
Pattern reasoning			
Child diet diversity	0.66	0.29	.001
HAZ score	2.69	0.94	.012
Wealth status	1.24	0.53	.018
Adj. R^2	0.197		
Short term memory			
Mothers education	0.73	0.23	.002
Child diet diversity	1.17	0.41	.005
Adj. R^2	0.222		
Visual processing			
Child diet diversity	1.38	0.41	.014
Mothers education	0.74	0.32	.017
HAZ score	−2.73	0.93	.019
Adj. R^2	0.356		
School achievement			
RCPM	0.53	0.15	.001
Years of pre-school attendance	2.07	0.67	.003
Pattern reasoning	0.58	0.19	.004
HAZ score	−6.79	0.45	.005
Mothers education	0.97	0.39	.011
Wealth index	0.91	0.44	.018
Adj. R^2		0.393	

[a]Ravens colored progressive matrices.
*Code (1 rural, 2 urban).
[∅]Height-for-age z score (code; 1 normal, 0 stunted).

Cognitive performance of children in this study was also predicted by several socio economic and child variables. Child Diet diversity was strongly associated with planning ability, short-term memory, and visual processing. This implies that children who consumed different food groups had higher mean cognitive test scores in relation to those who consumed lower food variety. A study done in Kenya reported that children with improved food quality in terms of diversity had better cognitive performance than those who consumed poor quality food.[23] A similar result was also reported from Ethiopia that children with higher diet diversity had significantly higher mean scores in most cognitive performance tests.[24]

Limitation of the Study

This study has its own limitations. Variables such as genetic variations which were not measured in this study could be potential confounders of cognitive function and school achievement. Micronutrient deficiencies and other environmental stimulations which can significantly affect cognitive development of children were also not assessed in this study. There is lack of a standardized cognitive performance testing system which is designed specifically in our country context. Therefore some tests were adapted from the KABC-II to make them more culturally appropriate and some tests have been omitted.

In this study we used midyear average examination result to estimate the school performance of children which is very short period and may be underestimate the real performance of children at school.

Conclusions

Based on findings of this study, the mean cognitive function test scores and school performance of rural study participants were relatively low as compared to urban counterparts in most of cognitive performance tests. Lower cognitive function test scores and poor school performance of study participants were significantly associated with poor nutritional status indicating the fact that under nutrition has long term negative consequences on physical and cognitive development of children and this might affect their potential to perform academically. Most of socio-demographic and economic variables were related with child cognitive performance test scores and school performance. Maternal education and wealth index were positively associated while stunting was negatively associated with cognitive function test scores and school performance of study participants. Child diet diversity had positive correlation with cognitive function test scores of children. RCPM and the Pattern Reasoning test had positive correlation with school performance of children. Years of pre-school education also contributed positively for RCPM and school performance of study participants in this study. Further study should be done at the community level with large samples to confirm the real differences and to generalize the findings to the whole population. Associations among micronutrient status, cognitive performance, school achievement, and other environmental stimulations were not studied in this survey and are recommended for further study.

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Author Contributions

TH had conceived and designed the study. All the Authors (TH, TB, FW, DH, and BS) performed the statistical analysis, involved in the interpretation of findings, and manuscript preparation. Finally, all the authors read and approved this manuscript.

Declaration of Conflicting Interests

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Ethical approval was obtained from Institutional Review Board of Hawassa University. Letter of permission was obtained from Zonal and District Health and Education Offices. Verbal assent and informed (written) consent was obtained from children and their parents or care-givers with signature or fingerprint.

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Availability of Data and Materials

The data sets analyzed during the current study are available from the corresponding author upon reasonable request.

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