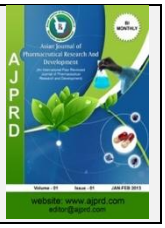
Available online on 15.10.2023 at http://ajprd.com

Asian Journal of Pharmaceutical Research and Development

Open Access to Pharmaceutical and Medical Research



Open Access

Research Article

Effect of Nutrition Intervention on Cognitive Function of Children Aged Between 6 and 12 Years – A Study from South India

Dr. Anitha. R*, Dr. Pa. Raajeswari

[1]Assistant Professor (GL), Department of Foods and Nutrition, Muthurangam Govt Arts College (A), Vellore-632002, Tamilnadu, India.

[2]Associate Professor, Department of Food Science and Nutrition, Avinashilingam Institute of Home Science and Higher Education for Women, Coimbatore-641 043, India.

A B S T R A C T

Nutrition is a fundamental cornerstone of good health, productivity, and overall functional capacity. Food that is safe, plentiful, and nutritious is essential for child growth and development. Children who do not grow properly during childhood may not be able to compensate for the growth loss later in life, even with an adequate diet. This study aimed to evaluate the impact of supplementation of the formulated health mixes which weremade out of selected potential ingredients for undernourished children and nutrition education on child nutrition to their mothers. Based on the inclusion criteria, it is designed as an intervention study with 90 children aged 6 to 12 years. Children were divided into three groups (CG, EGI, and EGII), each with 30 children. The raw materials were obtained, processed, powdered, and blended to create a health mix for three months of supplementation. The children were able to take 50gm of health mix each day as mid-morning and mid-evening snacks in the form of ladoos. The results showed that the children in Experimental Group II who got health mix supplementation as well as health and nutrition education for their mothers improved in nutritional status and cognitive performance. This study provides fresh insights for future policy and intervention programs.

Keywords: Poor Nutrition, Intelligence quotient, Health Mix, Supplementation, Nutrition Education

A R T I C L E I N F O: Received 16 June. 2023; Review Complete 02 Sept. 2023; Accepted 28 Sept. 2023; Available online 15 Oct. 2023

Cite this article as:

Anitha. R, Raajeswari Pa, Effect of nutrition intervention on cognitive function of children aged between 6 and 12 years – A study from South India, Asian Journal of Pharmaceutical Research and Development. 2023; 11(5):21-27.

DOI: http://dx.doi.org/10.22270/ajprd.v11i5.1316

*Address for Correspondence:
Dr. Anitha. R, Department of Foods and Nutrition, Muthurangam Govt Arts College (A), Vellore, Tamilnadu, India.

INTRODUCTION

Good nutrition can help young children grow, develop, survive, play, learn, participate, and become involved. Contrarily, inadequate nourishment puts children's lives and futures in jeopardy[1].One of the most important health issues affecting children in low- and middle-income nations, including India, is undernutrition. Poor nutrition is caused by insufficient food consumption or the absence of important nutrients for good health, growth, and development. Poor nutritional status leads to stunting which is characterised by low height for age, underweight by low weight for age and wasting by low weight for height and micronutrient deficiencies by low intake of vitamin and mineral[2].Undernourished children have weaker immune systems, which increases their chance of developing more severe, frequent, and long-lasting illness bouts. Additionally, it causes infections to recur, which might make the child's situation worse by making the state of more significant nutritional needs at a time. This correlation of undernutrition with infection creates a vicious cycle of poor nutritional status and morbidity[3].Nutritional deficits have two effects on brain development. It has an immediate impact on brain processes and an indirect impact on children's behaviour and perception[4]. According to Marconi *et al*., (2016)[5], children who have brain impairment, delayed physical growth, and lethargy do not explore their surroundings due to a lack of intellectual stimulation. Delayed developmental milestones in children can result in decreased parental expectations and have an

impact on intellectual advancement. The health status of children during school years impacts their nutritional status, cognitive development and subsequently affects their educational achievement.[6]Poor cognition and low intelligence among school children eventually contribute to various problems in physical, psychological and social well-being. Peer group influences also affect the quality of life when adulthood is attained. Improper cognitive function of a child is also associated with low socio-economic status, educational level of parents and maternal schooling, childhood infection, malnutrition, micronutrient deficiencies and hearing impairment[7]. During this early stage, the brain has a high demand for nutrients, and nutritional inadequacies impair normal neurodevelopment, resulting in long-term cognitive deficits. Hence, it is crucial to comprehend metabolic factors and specific nutrients to establish successful nutrition intervention strategies[8].The school children are consuming too much of sugary foods and beverages, and processed grains instead of including foods that help promote health, namely, whole grains, legumes, vegetables and fruits among school children predisposing them to various health problems even at a younger age. New research reveals that 69 per cent of over 23,000 packed food items have poor nutritional quality, with the highest proportion among low and middle-income countries than high-income countries[9].

Commercially fortified foods are not available, particularly in rural areas or where they are always so expensive in developing or underdeveloped countries, beyond the reach of most families. The majority of supplementary foods used are therefore, grown locally and based on local staple foods, usually cereal processed into porridges. The most effective multigrain supplementation is a common and convenient way for food formulations used by combining different grains to make the end product more nutritious and richer in other health constituents. There is an absence of safe and healthy food choices for children in confronted with an abundance of low-quality foods with high calories, low nutritious and processed foods cause the greatest risk of undernutrition[10].Schools are considered an ideal environment for health promotion activities among children. The educational strategies in any combination, supported by the environment, promote the adoption of different dietary choices and nutritional behavior, facilitating good health and well-being. Nutrition education can be delivered through multiple venues and includes various actions for individuals, communities and policy levels[11].

The children who had malnutrition in the early years may have a lower attendance percentage and secured poor cognitive test scores in school years compared to children with good nutrition[12]. The significance of the educational status of mothers on child nutrition has been well demonstrated in various research. The mother's education is highly associated with the child's health and nutritional status by improving the mother's socio-economic status. Imparting nutrition education to mothersfor improving the knowledge on etiology, consequences, prevention and treatment of diseases[13].The state of nutrition and intelligence among children requires attention from all. This study aimed to assess the impact of nutrition intervention on the nutritional status and intelligence quotient level of children through the supplementation of prepared health mix and post-test evaluation of nutrition education to mothers.

MATERIALS AND METHODS

Selection of the Area and Sample

It is an interventional study that was carried out in three public schools in Vellore, Tamil Nadu, India, between November 2018 and March 2019 after receiving official permission from the chief educational officer and school authorities, as well as ethical approval from the Institutional Human Ethics Committee of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore (AUW/IHEC-18-19/FSN/FHP-07). The children in the intervention study were divided into three groups: Experimental Group I (EG I), which received nutrition education using the Personalised Nutrition Education Package (PNEP), Experimental Group II (EG II), which received supplementation of 50g of health mix in addition to the PNEP, and Control Group (CG), which received no intervention for three months. Nutritional anthropometry, clinical examination, dietary profile, and cognitive function assessment were used to evaluate the impact of nutrition intervention and nutrition education. The written informed consent was obtained from the parents after giving detailed instructions about the study.

Tools used for the study

A self-structured pre tested interview schedule was used for collecting general information. Anthropometric measurements such as height, weight, body mass index (BMI) of the children were recorded accurately before and after intervention and categorized the children's nutritional status based on 2007 WHO Growth Charts[14]. Raven's Colored Progressive Matrices (RCPM) scale[15]was administered to assess the intelligence quotient level of the children.

Identification, selection and processing of ingredients for health mix

The commonly used cereals and millets namely red rice, whole wheat, bajra, foxtail millet and rice flakes were selected for their higher potential dietary sources. Pulses including soya bean, green gram and roasted bengal gram dhal were used for their rich protein source. Brahmi leaves (VallaraiKeerai) (Centella asiatica L.) are popular natural brain stimulating substances. Brahmi leaves were included in the health mix due to their ability to improve brain functions and memory. Jaggery was chosen because of its sweet taste, palatability, and high iron content. These ingredients were chosen due to their higher potential source of calorie, protein, fat, iron, calcium, zinc and selenium, which influence effective brain function.

Preparation of health mix for supplementation

Based on the results of the acceptability trial and nutrient analysis, Health Mix III obtained the highest overall rating scores and was chosen for supplementation. Raw ingredients of the Health Mix III were procured in bulk from the local market. They were processed, mixed in an appropriate proportion and milled in the flour mill.The processing chart

of the health mix is given in Figure 1. The prepared health mix powder was packed in 25g pockets for easy distribution.

Determination of quantity of health mix for nutrition intervention

The children were able to take 50gm of health mix each day as mid-morning and mid-evening snacks in the form of ladoos. Each child in the Experimental Group II received 6 packets of health mix at three-day intervals, with each pocket containing 25gm of health mix for two sessions each day and the instruction was to consume one pocket (25gm) every session.Mothers were instructed to give the health mix for three months in the form of ladoos, which can be prepared using hot water.

Conducting nutrition education program to mothers regarding child nutrition

The mothers of selected children received personalized nutrition counseling about child nutrition. They were instructed to report to the school on Mondays. The researcher made herself available to provide personal nutrition counseling to the mother based on the children's needs for three months using the newly developed PNEP.

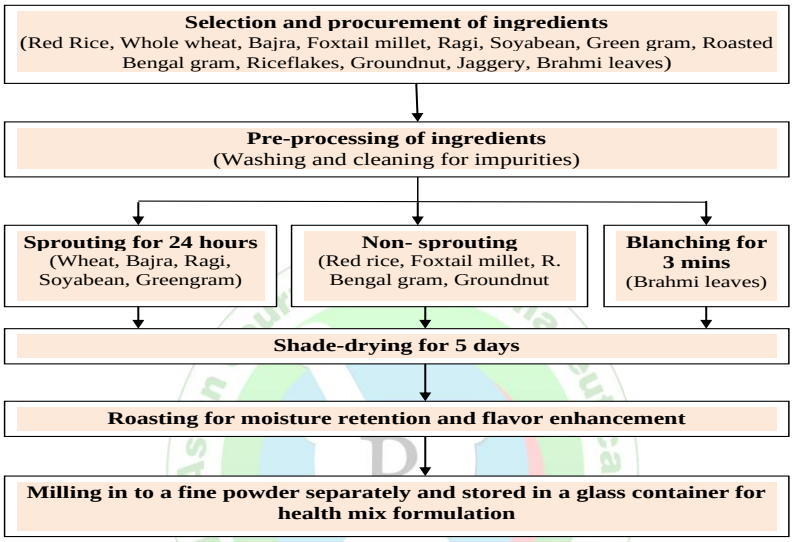


Figure 1: Processing of health mix ingredients

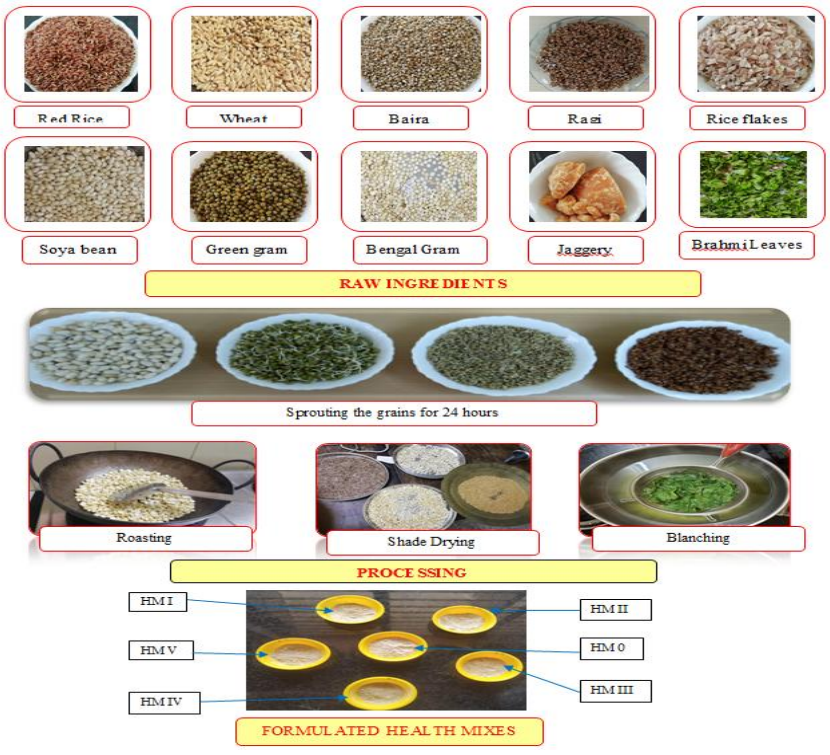


Figure 2: Health Mix Formulation

Statistical Analysis

The collected information was consolidated, and the results were compared within and between the groups. SPSS version 16.0 was used for the analysis of statistics including descriptive statistics, student t-test and correlation.

RESULTS AND DISCUSSION

Impact of nutrition intervention on anthropometric measurements of the selected children

The mean height of the children in EG II was increased from 112.7 cm to 114.3 cm after three months of the health mix supplementation along with nutrition and health education using PNEP. The increases in mean final height revealed that the children had grown much taller (P =< 0.000) than the other groups in the study. However, the mean difference revealed that EG-II improved the most (1.55 cm), followed by EG-I (1.2 cm), and the Control Group improved the least (0.5 cm).Osei et al., (2017)[16] discovered that the mean height for age of the treatment children was significantly higher at post-intervention compared to the baseline survey due to the effect of an Enhanced Homestead Food Production (EHFP) programme, specifically home gardening, nutrition education, and poultry raising in rural areas of Nepal's Baitadi District.According to Christian et al., (2015)[17], small quantities of supplemental foods delivered daily to children in rural Bangladesh for a year, along with nutrition education, marginally boosted linear growth and efficiently reduced stunting at 18 months.

Table 1: Effect of Nutrition Intervention on Anthropometric Data of the Selected Children (N=90)

Study Groups	Before Mean ± SD	After Mean ± SD	Mean Difference	't' Value	Groups Compared	t' Value
Height (cm)						
EG I	112.2 ± 4.3	113.4 ± 4.4	1.20	5.0***	CG Vs EG1	3.8***
EG II	112.7 ± 7.6	114.3 ± 7.3	1.55	5.9***	CG Vs EG2	4.9***
CG	121.4 ± 8.5	121.9 ± 8.4	0.50	2.4***	EG1Vs EG2	0.5^{NS}
Weight (kg)						
EG I	16.8 ± 1.4	18.7 ± 1.7	1.82	10.1***	CG Vs EG1	4.6***
EG II	16.8 ± 2.4	18.9 ± 2.4	2.07	14.9***	CG Vs EG2	5.3***
CG	21.9 ± 3.2	22.2 ± 3.2	0.25	13.4***	EG1Vs EG2	0.4^{NS}
Body Mass Index (BMI)						
EG I	13.4 ± 0.8	14.5 ± 1.1	1.07	6.88***	CG Vs EG1	1.2^{NS}
EG II	13.3 ± 0.8	14.6 ± 0.7	1.27	10.06***	CG Vs EG2	1.3^{NS}
CG	14.9 ± 1.9	14.9 ± 1.8	0.07	1.14^{NS}	EG1Vs EG2	0.4^{NS}

The body weight of the children in EG-II increased by 2.07kg on average after health mix supplementation combined with health and nutrition education to mothers, and the selected children gained the most weight compared to other groups, highlighting the benefits of health mix supplementation and nutrition education combined for a better outcome. Kristjansson et al., (2015)[18] found that supplemental feeding in children had a positive effect on growth and development over six months, with them gaining 0.25kg more than the control group. The current study's findings are similar to those of Durairaj et al., (2019)[19], who discovered that supplementing multi millet health mix to primary school children in Coimbatore District, Tamilnadu increased their mean weight by 2.65kg in the experimental group. The increment in Body Mass Index of the children was observed after the nutrition intervention in experimental group I and II. The children's BMI increased from 13.3 to 14.6 in Experimental Group II and obtained the highest significant (P = 0.0001) improvement in BMI with the mean difference at the range of 1.27 after intervention. However, the highest 't' value of 1.2 and 1.3 reported an excellent difference between the control and experimental groups. Since the developed health mix in the present study is having potential source of zinc could improve weight gain by increasing appetite among undernourished children in EG-II.Grover *et al.,* (2020)[20] revealed that the supplementation of maize protein-based biscuits to the children significantly reduced the incidence of the severe underweight rate of 23.34 percent to zero which is on par with the results of the present study. The prevalence of severe thinness was totally eradicated in both the two experimental groups (EG I and EG II).After the nutrition intervention program, the ratio of healthy children increased by 43.3 per cent in EG I and 50 per cent in EG II after the intervention program. The severe thinness prevalence among the selected children was totally eliminated both in EG I and EG II, but, the highest improvement was observed in EG III in comparison between these two groups. Overall, the nutrition intervention strategies efficiently reduced the incidence of stunting, underweight and thinness among children in the selected groups and helped to improve children's nutritional status.Another study also reported that

taking 10 mg of zinc per day for 12 to 24 weeks can boost appetite, growth and weight gain in undernourished children and that zinc supplementation has a major impact on growth, appetite and development among children[21].

Effect of nutrition intervention on the cognitive functions of children

The 't' test results revealed that there is a significant difference at less than 1 percent levelobtained between before and after nutrition intervention in all the segments of cognitive test scores in EG I and EG II. However, the highest level of improvement in cognitive test scores was found in EG II rather than in EG I. The control group did not show much difference in the cognitive test scores except Set B. The mean Set A score was increased from 5.97 to 9.3 in EG I, 6.3 to 9.8 in EG II and 8.13 to 8.8 in CG. The mean Set AB, Set B and the total scores of children in EG I was increased from 4.37, 3.13 and 13.53 to 8.6, 8.4 and 26.2 respectively after the nutrition intervention. Similarly, Set AB, Set B and total RCPM scores of children in EG II were increased from 4.4, 3.3, 14.0 to 9.7, 9.7 and 29.2, respectively. The highest improvement in age equivalent noticed was in EG II after the nutrition intervention. Richardson and Montgomery, (2005)[22] revealed that fatty acid and other cereal based foods offered a safe and effective supplementation option for the improvement of educational, behavioral problems and cognitive function among children with developmental delay.Even though both experimental groups had a significant impact on intelligence quotient levels, EG II had the highest degree of change between before and after intervention than EG I. The study's overall findings demonstrated that supplementing the health mix with health and nutrition education had a significant positive effect on the children's intelligence quotient level. Roberts et al., (2020)[23] investigated the effect of blended fortified meal supplementation on children's working memory and cerebral blood flow in undernourished children in low-income nations. The findings of their study showed that children's executive function, brain health, and nutritional status improved, which is similar to the findings of the current study. According to De Moura et al. (2013)[24], zinc supplementation among schoolchildren significantly improved their academic performance and cognitive skills .

Table 2: Cognitive Test Scores of the Children Before and After Nutrition Intervention (N = 90)

Cognitive Test S	EG I			EG II			CG		
	Before	After	"t"	Before	After	"t"	Before	After	"t"
SET A	5.97 (2.4)	9.3(1.2)	2.3***	6.3(2.3)	9.8(0.9)	2.5***	8.13(2.3)	8.8(1.7)	1.7^{NS}
SET AB	4.37(2.4)	8.6(1.1)	3.2***	4.4(2.5)	9.7(0.8)	4.4***	6.37(3.1)	6.77(2.6)	3.0*
SET B	3.13(1.9)	8.4(0.8)	4.5***	3.3(1.5)	9.7(0.8)	5.8***	5.3(2.9)	6.1(2.5)	4.9**
Total Score	13.53(5.3)	26.2(1.7)	10.4**	14.0(4.9)	29.2(1.5)	13.4***	19.57(7.5)	21.7(5.5)	3.1*
Age Equivalent	4.52(2.3)	5.65(3.5)	1.7***	4.32(2.9)	6.52(2.6)	2.8***	7.51(2.5)	7.91(1.1)	1.2^{NS}

Effect of nutrition education on the knowledge scores of mothers of undernourished children

The impact of nutrition education intervention was assessed using pre and post-test questionnaires consisting of 20 multiple choice questions among the three intervention groups. Impact evaluation of nutrition intervention on the knowledge level of the mothers regarding child nutrition is presented in Figure 3.

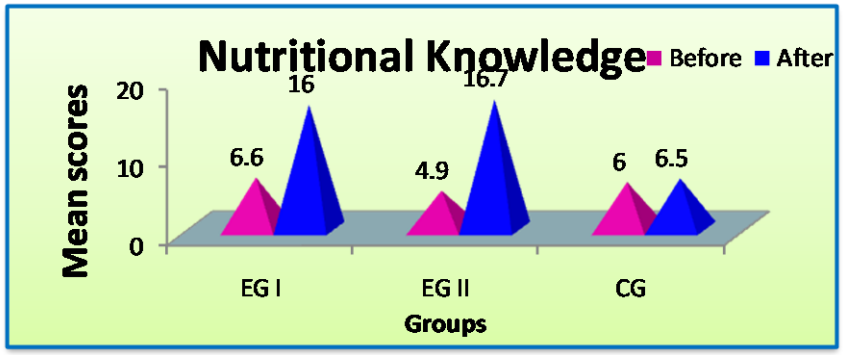


Figure 3: Nutrition Intervention on Knowledge Level of Mothers

It was encouraging to note that nutrition education had a positive effect on the KAP scores. As far as nutritional knowledge is concerned, the mean scores of EG I and EG II increased from 6.6 to 16 and 4.9 to 16.7 after the nutrition education was imputed with the help of PNEP for three months consistently. The statistical significance at less than

1 percent level of difference was obtained for the mother's knowledge in EG I and EG II before and after nutrition intervention. There was no statistically significant difference found among the control groups before and after the three months of intervention. The highest mean difference was found in terms of nutrition knowledge among EG II, indicating the effect of supplementation and nutrition and health education. According to the findings of Osei*et al*., (2017)[16], an integrated intervention involving home gardening and change in nutrition behavior helped to improve household food security, maternal hygiene, child health and prevention of underweight which also coincides with the results of the present study. A cluster-randomized intervention study in Southern Ethiopia had found that pulse-based nutrition education to mothers resulted in a substantial improvement in children's nutritional status, suggesting that nutrition education to mothers may infact be a successful strategy in improving the health and nutritional status of children from Ethiopian communities (Teshome *et al*., 2020)[25].

Conclusion

Nutritional supplements combined with health education produced the greatest potential for development in anthropometric measurements. It was encouraging to see improvements in cognitive function, as measured by the intelligence quotient level and academic performance, along with growth. Despite coming from middle-class households in both rural and urban locations, all of the children's home-cooked meals were low in practically all nutrients. Regular supplementation of a nutritious health mix could significantly reduce the nutritional gap and pave the path for significantly better nutritional status, cognitive function, and academic activities. Asimilar conclusion was reached by teachers and parents, who stated that the children who consumed the supplement improved and showed evidence of alertness in class activities.

Acknowledgments

The authors are thankful to all the study participants for their kind cooperation. Authors are also grateful to authors/ publishers of all those articles from where the literature for this article has been reviewed and discussed.

Conflict of Interest: Nil

REFERENCES

1. Anitha R, Raajeswari Pa. Nature, Prevalence, and Impact of Undernutrition on Intelligence Among School Children: A Cross-Sectional Study from South India. ECS Transactions, 2022; 107 (1): 637-646.
2. Singh, A., & Sharma, R. (2022). A study for the Assessment of Nutritional Deficiency Status of the School Going Girls. Integrated Journal for Research in Arts and Humanities, 2(3), 78-82.
3. Siddiqui, F., Salam, R. A., Lassi, Z. S., & Das, J. K. (2020). The intertwined relationship between malnutrition and poverty. Frontiers in Public Health, 8, 453.
4. PradoE. L, and DeweyK.G, Nutrition and brain development in early life. Nutrition reviews, 2014; 72 (4): 267-284.
5. Marconi, S., Noel, J., Jacob, K., & Prasad, J. (2016). Nutritional status and intellectual development in children: A community-based study from rural southern India. The National Medical Journal of India, 29(2), 82-84.
6. KarakP, Maiti R, Das P, and Karmakar A. Assessment of nutritional status of school children in rural and urban areas of Bankura, West Bengal. Int J Pharm Sci Res, 2018;9 (1):338-45.
7. Poh, B. K., Lee, S. T., Yeo, G. S., Tang, K. C., Afifah, A. R. N., Hanisa, A. S., and Ng, A. L. O. (2019). Low socioeconomic status and severe obesity are linked to poor cognitive performance in Malaysian children. BMC Public Health, 19 (4), 1-10.
8. Spencer S. J, KorosiA, LayéS, Shukitt-Hale, and Barrientos R. M. Food for thought: how nutrition impacts cognition and emotion. NPJ Science of Food, 2017; 1(1):1-8.
9. Global Nutrition Report. Shining a light to spur action on nutrition. Retrieved from Bristol. UK (2018).
10. Sethy, S, and Mogra R. An Assessment of Nutritional Status of under-five Children in Rural Area, Udaipur, Rajasthan, India. Int. J. Curr. Microbiol. App. Sci, 2020; 9 (6):3947-3953.
11. ContentoI. R. Nutrition education: linking research, theory, and practice, Jones and Bartlett Publishers, Sudbury, Canada, 2007.
12. Haile D, Nigatu K, Gashaw, and Demelash H, Height for age z score and cognitive function are associated with Academic performance among school children aged 8–11 years old. Archives of Public Health, 2016; 74 (1):17.
13. Makoka D, and MasiboP.K. Is there a threshold level of maternal education sufficient to reduce child undernutrition? Evidence from Malawi, Tanzania and Zimbabwe. BMC Pediatrics,2015; 15 (1):96.
14. World Health Organisation (WHO). Growth reference data for 5-19 years, https://www.who.int>growth ref; 2007.
15. Smirni D. The Raven's Coloured Progressive Matrices in Healthy Children, A Qualitative Approach. Brain Sciences, 2020; 10 (11): 877.
16. OseiA, PandeyP, NielsenJ, PriesA, SpiroD, Davis D, and HaselowN. Combining home garden, poultry, and nutrition education program targeted to families with young children improved anemia among children and anemia and underweight among non-pregnant women in Nepal. Food and Nutrition Bulletin,2017; 38 (1): 49-64.
17. ChristianP, ShaikhS, Shamim A. A, Mehra S, WuL, MitraM, and West JrK P. Effect of fortified complementary food supplementation on child growth in rural Bangladesh: a cluster-randomized trial. International journal of epidemiology,2015;44(6):1862-1876.
18. KristjanssonE, FrancisD. K, Liberato S., Jandu, M. B, WelchV, Batal Mand PetticrewM. Food supplementation for improving the physical and psychosocial health of socio-economically disadvantaged children aged three months to five years: a systematic review. Campbell Systematic Reviews, 2015; 11(1):1-226.
19. DurairajM, Gurumurthy G, Nachimuthu V, Muniappan K, and Balasubramanian, S. Dehulled small millets: The promising nutria cereals for improving the nutrition of children. Maternal and child nutrition, 2019; 15:12791.
20. Grover K, AroraS, and ChoudharyM. Development of quality protein product using biofortified maize to combat malnutrition among young children. Cereal Chemistry, 2020; 97(5): 1037-1044.
21. ChaoH. C, Chang Y. J, and Huang W. L. Cut-off Serum Zinc Concentration Affecting the Appetite, Growth, and Nutrition Status of Undernourished Children Supplemented with Zinc. Nutrition in Clinical Practice, 2018; 33(5): 701-710.
22. Richardson, A. J., & Montgomery, P. The Oxford-Durham study: a randomized, controlled trial of dietary supplementation with fatty acids in children with developmental coordination disorder. Pediatrics, 2005; 115(5):1360-1366.
23. RobertsS. B, Franceschini M. A, Silver R. E, Taylor S. F, de Sa A. B, Có R and MuentenerP. Effects of food supplementation on cognitive function, cerebral blood flow, and nutritional status in young children at risk of undernutrition: Randomized Controlled Trial. BMJ, 2020: 370.
24. De Moura J. E, de Moura E. N. O, Alves C. X, de Lima Vale S. H, Dantas M. M. G, de Araújo Silva A, and Brandão-Neto J. Oral zinc supplementation may improve cognitive function in schoolchildren. Biological trace element research, 2013; 155(1): 23-28.

25. Teshome, G. B., Whiting, S. J., Green, T. J., Mulualem, D., and Henry, C. J. Scaled-up nutrition education on pulse-cereal complementary food practice in Ethiopia: a cluster-randomized trial. BMC Public Health, 2020; 20 (1):1-12.